Report by the Chair on the 43rd North East Regional Stock Assessment Review Committee (SARC)*

By

Robin Cook

Prepared for

University of Miami

Center for Independent Experts

44 North Deeside Road
Bieldside
Aberdeen
AB15 9DR
UK

** The NEFSC SAW Chairman has omitted sections of this report that deal with ocean quahogs. The ocean quahog assessment has been withdrawn because it did not include all available data and an important formula needs to be corrected. The decision by the NEFSC to withdraw the assessment was made before the SARC43 reviews were available. This action was approved by the NRCC. The ocean quahog assessment will be reviewed by the next SARC in late 2006. (This note was written by James Weinberg, NEFSC SAW Chairman, July 10, 2006.)*

Contents

Executive Summary

1. The meeting of the 43th SARC reviewed assessments of spiny dogfish, ocean quahog, black sea bass and deep-sea red crab. The Panel comprised Robin Cook (chair), Mark Maunder and Mike Armstrong, all representing CIE.

Deep Sea Red Crab

2. The assessment of this stock is predicated on recent under-water camera surveys. The panel believed that the assessment was adequate to provide estimates of biomass and fishing mortality rate, but that the current biological reference point is no longer appropriate for management purposes.

    2.1 The commercial catch, discards and their uncertainty were characterized appropriately.

    2.2 Fishing mortality and biomass were estimated appropriately and provide scientifically credible basis for developing fishery management advice provided the uncertainty regarding assumptions is taken into consideration. It was considered that the low estimated fishing mortality rate was indicative of the likely level of fishing mortality. The observation that the change in population structure where large males are now largely absent from the survey was regarded as robust. There appears to be an increase in the densities of smaller crabs in the recent survey size compositions.

    2.3 Biological reference points were not updated. The current biomass reference point is not considered to be reliable.

    2.4 Current stock status with respect to the existing Biological Reference Points (BRPs) was not evaluated.

    2.5 Data were inadequate to provide scientifically credible projections.

    2.6 No projections could be provided.

    2.7 There were no research recommendations from the previous assessments.

Ocean Quahog

3. (text omitted).

Spiny Dogfish

4. The main concerns for this stock are the reduction in female abundance, imbalance in the sex ratio, and the low estimates of recent recruitment. Discards contribute significantly to the fishing induced mortality and need to be monitored. The current biomass and fishing mortality estimates are strongly influenced by a very large survey estimate in 2006. This is unlikely to be reliable and probably

gives an overoptimistic view of the current state of the stock and an overoptimistic view of future stock development under *status quo* fishing mortality.

4.1 The commercial and recreational catch, discards, and their uncertainty were characterized appropriately. Discards comprise a very large component of the fishery but discard rates for early years and discard survival are uncertain.

4.2 Biomass was estimated using the swept area survey method and fishing mortality was estimated as catch divided by biomass from a three year moving average. A consistent decline in the average size of females in all surveys supports an impact of the fishery on the females.

4.3 It is not clear if the reference points are appropriate to provide scientifically credible advice. The reviewers felt that $B_{threshold}$ was adequate but that there was substantial uncertainty about the reliability of B_{target}. The fishing mortality reference point is very sensitive to selectivity, which changes substantially over time and its absolute value needs to be interpreted with considerable care.

4.4 Evaluating the stock status with respect to the reference points is problematic. The level of uncertainty is such that the biomass may well be below $B_{threshold}$. The estimate of current fishing mortality of F=0.13 is close to the existing $F_{threshold}$ of 0.11 but well below the revised estimate of 0.387 but is uncertain and may be underestimated.

4.5 The Working Group determined that uncertainty in the recreational catch had little impact on the assessment results.

4.6 The Working Group recommended the approach used by SAW37 for projections, which is the stochastic length-based projection model. The projection model should be modified to be consistent with the other models used for assessment and reference points.

4.7 Sample projections were provided and the method used is appropriate for the swept-area assessment data providing the starting population and F vector. The projections do not provide a quantitative basis for advice on management.

4.8 Nine of the eleven research recommendations were completed or in progress.

Black Sea Bass

5. The assessment was not considered to provide an adequate basis to evaluate stock status against BRPs. There were inconsistencies in the tagging data analysis that undermine its validity in the estimation of fishing mortality rate. It was also felt that the biological reference points were not established on a sound basis.

5.1 The time-series of commercial and recreational landings were updated to include 2005 data, and a breakdown was given by gear type. Limited information on discards was available.

5.2 The temporal trends in abundance and size-structure based on data from NEFSC surveys and their uncertainty were characterized. However, there was inconsistency about the best methods to represent the index values and their uncertainty. Confidence intervals were large and it is questionable whether the trends can be used to evaluate stock status.

5.3 This ToR (migration patterns based on a recent tagging study) was completed. A clear and consistent pattern of seasonal alongshore and cross-shelf patterns of migration are evident, and the tagging programme has provided a substantial contribution to understanding of the migration patterns in this species.

5.4 Tagging data were used to estimate fishing mortality but the results were not considered to be adequate for management purposes.

5.5 The current stock status was evaluated with respect to BRPs. Current estimates of fishing mortality and stock biomass were not regarded as providing a sound basis to evaluate stock status for management purposes. Current BRPs were not regarded as sound and need to be reconsidered.

5.6 Estimates of precision of the recreational catches were calculated and the sensitivity was investigated using the LTM. The results of the model were not markedly affected by replacing these values with average values. However, the LTM model is not used for the assessment.

5.7 Research recommendations related to improving the sampling of commercial and recreational catches, estimating confidence limits for recreational catches and development of a standard assessment based on a population model were addressed. Little or no progress was made on the remaining nine recommendations.

Background

The meeting of the 43th SARC began at Wood's Hole, MA on the 6th June to review assessments of spiny dogfish, ocean quahog, black sea bass and deep-sea red crab. The Panel comprised Robin Cook (chair), Mark Maunder and Mike Armstrong, all representing CIE. They were assisted by the SAW chair, Jim Weinberg, and the Head of the NEFSC Population Dynamics Branch, Paul Rago. The meeting was attended by a number of scientists from the NEFSC, staff from the New England Fishery Management Council, the Atlantic States Marine Fisheries Commission and representatives of the fishing industry.

Approximately two weeks prior to the meeting the assessment documents and supporting material were made available to the panel on the NEFSC website. More documents were added as they became available up to and during the meeting.

Mark Maunder agreed to act as the SARC leader for the assessments of spiny dogfish and ocean quahog. Mike Armstrong did the same for Black Sea bass and deep sea red crab. The SARC chair and Mike Armstrong met with the SAW chair and Paul Rago on the evening of the 5th June to discuss the SARC meeting arrangements and finalise preparations.

Review of Activities

The first day of the meeting was devoted to reviewing the ocean quahog and spiny dogfish assessment reports. The quahog assessment was presented by Larry Jacobson of the NEFSC with additional input from Robert Russell from the Maine Department of Marine Resources in relation to the Maine component of the quahog stock. Following the presentations, the panel asked the lead presenter to prepare a document summarising how the assessment team had met the terms of reference. The panel also requested that various errors noted during the presentation should be documented and circulated.

The spiny dogfish assessment report was presented by Paul Rago with an additional presentation by Paul Nitschke on the Length Tuned Model (LTM). Following the presentation, the panel requested further discussion on the assessment for the following day.

The black sea bass assessment was presented by Gary Shepherd on the morning of the 7th June. At the request of the Panel, the presentation followed each term of reference so that the extent to which the assessment team had met the terms of reference could be more easily judged. Paul Nitschke also presented the results of the LTM model applied to this stock. The presentations and discussion of the assessment was completed during the session.

Further discussion of the ocean quahog assessment took place on the afternoon of the 7th June using the additional information supplied by Larry Jacobson at the request of the panel. Discussion was structured around the terms of reference in order that the Panel could discharge its role in evaluating the extent to which they had been successfully addressed. Following this discussion the Panel were satisfied that they were in a position to evaluate the assessment.

On conclusion of the quahog discussion, the Panel returned to the spiny dogfish assessment. This discussion was also structured around the terms of reference. During the discussion the panel requested additional information on the discard length distributions by fleet segment and additional estimates of the fishery selectivity pattern assuming that maximum selectivity was reached within the size range of the observed survey catch composition. Notwithstanding this request, the panel concluded its main discussion of this assessment.

The deep sea red crab assessment was presented by Rick Wahle of the Bigelow Laboratory on the morning of the 8^{th} June with assistance from Larry Jacobson. Discussion of the assessment continued in the afternoon and examined the assessment against the terms of reference. Additional material requested by the panel on annual estimates of biomass for the 2003-2005 surveys was also reviewed. The panel concluded its deliberations on this assessment and then returned to discuss the additional requested material provided by Paul Rago on the spiny dogfish. Once this material had been reviewed the Panel were satisfied that they were in a position to prepare their review reports. The public meeting of the SARC was closed at 5 pm on the 8^{th} June.

Comments on the SARC process

The revised SARC process focuses more on the review by independent experts and less on the presentation of the assessments to the public. This is an important change of emphasis and suggests that there may be value in organising the presentation of assessments to that end. In terms of review, perhaps the greatest benefit of the SARC meeting is the opportunity to discuss the assessments with the relevant scientists and others at the meeting with pertinent expertise. It may be worth considering a format where it is assumed that the reviewers have already read the assessment documents and hence that an exhaustive detailed presentation of the assessment document is not required. It would be preferable to limit the main presentation to perhaps 40 minutes, focussing on the principal issues relating to the assessment such as data quality, the principal assessment tools used and their strengths/weaknesses, main conclusions about the status of the stock and issues relating to BRPs. A clear linkage in the presentation to the achievement of the terms of reference would be highly beneficial. This would then lead into a more focussed discussion of the assessment structured around the terms of reference. This might avoid the tendency with the present process of discussion on fine points of detail, rather than the main issues affecting the assessment.

Deep Sea Red Crab

The assessment of this stock is predicated on recent under-water camera surveys. The panel believed that the assessment was adequate to provide estimates of biomass and fishing mortality rate, but that the current biological reference point is no longer appropriate for management purposes.

1. *Characterize the commercial and recreational catch including landings and discards.*

The commercial catch, discards and their uncertainty were characterized appropriately.

There is no recreational catch for this stock and most of the available information relates to commercial landings only.

Catch data prior to 1992 are likely to be unreliable as there was no requirement to report in this period. Discard data are not available but it is believed that approximately 30% of the catch is discarded and this includes all female crabs. The survival rate of discards is unknown. The absence of discard information will affect the estimation of fishing mortality rate, and all other factors being equal, will result in an underestimation.

Historic length frequency data from the catch were thought to be uncertain due to low sampling coverage in some areas, changes in the fishery selection pattern and the heterogeneous distribution of the population by area and depth.

2. *Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.*

Fishing mortality and biomass were estimated appropriately and provide scientifically credible basis for developing fishery management advice provided the uncertainty regarding assumptions is taken into consideration.

Fishing mortality was estimated by dividing the commercial catch by the survey biomass estimate. This value will be affected by:

i. Uncertainty about discards and discard survival (negative bias in F)
ii. Limited coverage of the Northern and Southern ends of the stock distribution by the survey (negative bias in biomass, positive bias in F)
iii. Uncertainty about the area of suitable habitat used to expand the survey data (positive bias in biomass, negative bias in F)

However it was considered that the low estimated fishing mortality rate was indicative of the likely level of fishing mortality.

Biomass estimates for 2003/5 were considered sufficiently comparable to the 1974 survey despite changes in the survey instrumentation and probable changes in crab detectability. The estimated biomass will also be affected by (ii) and (iii) above. The observation that the change in population structure, where large males (114+mm) are now largely absent from the survey, was regarded as robust because this was reflected in a number of other surveys. There appears to be an increase in the densities of smaller crabs in the recent survey size compositions.

The characterisation of biomass by the working group as ‘fishable’ biomass was not regarded as sufficient to provide an indication of any change in the spawning potential of the stock and should not be used to measure the reproductive capability of the stock. This is further complicated by the reproductive behaviour of the crabs, which requires males to be at least 50% larger than females for successful mating. The panel felt that careful consideration should be given to developing appropriate measures of spawning biomass for this stock.

3. *Either update or re-estimate biological reference points (BRPs), as appropriate.*

Biological reference points were not updated.

The current biomass reference point is not considered to be reliable and the reviewers did not support its use for management. It is based on a size distribution of the catch of males that is no longer represented in the catch or the stock and is based on assumptions about the biology of crab, which is largely unknown.

There is currently no basis for estimating a fishing mortality rate reference point.

4. *Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).*

This was not done for the reasons given above.

5. *Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.*

Data were inadequate to provide scientifically credible projections for developing fishery management advice.

6. *If possible,*

    a. *provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and*

    b. *compare projected stock status to existing rebuilding or recovery schedules, as appropriate.*

See above

7. *Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.*

There were no research recommendations from the previous assessments.

Ocean Quahog

(text omitted).

Spiny Dogfish

The main concerns for this stock are the reduction in female abundance, imbalance in the sex ratio, and the low estimates of recent recruitment. Discards contribute significantly to the fishing induced mortality and need to be monitored.

The current biomass and fishing mortality estimates are strongly influenced by a very large survey estimate in 2006. This is unlikely to be reliable and probably gives an overoptimistic view of the current state of the stock and an overoptimistic view of future stock development under status quo fishing mortality.

The volume of analytical results made it quite difficult to evaluate the working group report in places, and future reports of this complexity should be structured in a more logical fashion with the key assessment data and results clearly highlighted.

1. *Characterize the commercial and recreational catch including landings and discards.*

The commercial and recreational catch, discards, and their uncertainty were characterized appropriately. The time series of fishery landings since the 1980s is likely to be adequate. The estimation of recreational catches uses a valid survey-based approach.

Discards comprise a very large component of the fishery but discard rates for early years and discard survival are uncertain. The figures for mortality of discards given in the report are based on very scant evidence, and it would be better to give assessment results for a plausible range of discard survival rates, so that worst-case scenarios can be evaluated against BRPs.

The method for estimating discards using total landings as a raising factor is very imprecise with large CVs. The quantity of discards has changed over time due to management regulations, economic factors, effort, and availability of the stock, among other factors. This has modified the length-frequency of the retained catches and influences estimates of selectivity.

The temporal and spatial pattern of dogfish landings are closely tied to the north-south migration patterns of the stock. There has also been a redistribution of abundance inshore over time.

2. *Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.*

Biomass was estimated using the swept area survey method and fishing mortality was estimated as catch divided by biomass from a three year moving average. A consistent decline in the average size of females in all surveys supports an impact of the fishery on the females.

Absolute estimates of abundance from surveys are the core of the assessment. This requires strong assumptions about the "footprint" of the survey gear. There are several factors that indicate uncertainties in this footprint. These include schooling behaviour, the degree of herding by the gear, a high proportion of zero tows and changes in gear performance by depth.

A key aspect of the dynamics of the stock has been a contraction in the length range in the stock, reflecting the impact of negligible recruitment in recent years coincident with a decline in relative abundance of large females in recent years. The average number of pups and average size of pups has been decreasing over time with the decreasing average size of females.

The LTM shows promise as an alternative method to estimate biomass and fishing mortality. However, there are several improvements that are needed before it would be suitable to provide credible scientific advice.

3. *Either update or re-estimate biological reference points (BRPs), as appropriate.*

It is not clear if the reference points are appropriate to provide scientifically credible advice.

The threshold fishing mortality reference point, which is based on the number of pups produced per female, was updated using the current selectivity pattern. The revised estimate (0.387) is much higher than in the previous assessment because selection has shifted toward older fish in recent years. This illustrates that the reference point is very sensitive to selectivity, which changes substantially over time and its absolute value as expressed in an F value needs to be interpreted with considerable care.

The Working Group considered that revising the biomass biological reference points based on the Ricker Stock-Recruitment model is unreliable because of the recent low recruitments that were not consistent with this model and suggested retaining the previous value. The reviewers felt that $B_{threshold}$ was adequate but that there was substantial uncertainty about the reliability of B_{target}.

4. *Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).*

Evaluating the stock status with respect to the reference points is problematic. The current swept-area biomass estimate for mature female spiny dogfish is close to the $B_{threshold}$ but well below the B_{target}. However the level of uncertainty is such that the biomass may well be below $B_{threshold}$.

The estimate of current fishing mortality of F=0.13 is close to the existing $F_{threshold}$ of 0.11 but well below the revised estimate of 0.387. The large average biomass estimate for 2004-2006, however, may give an under-estimate of current F. It should also be noted that selectivity, which is uncertain, plays an important part in the estimation of F.

5. *Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.*

The Working Group determined that uncertainty in the recreational catch had little impact on the assessment results. Most of the recreational catch is discarded, and the discard mortality is thought to be relatively low.

6. *Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.*

The Working Group recommended the approach used by SAW37, which is the stochastic length-based projection model.

The projection model (or the other models) should be modified to be consistent with the other models used for assessment and reference points. For example, the biomass reference points are based on a Ricker stock-recruitment model, but the projection model assumes recruitment proportional to females. If the LTM is improved and used in future assessments, it should also be used for projections. Variation in recruitment should also be included in the model.

7. *If possible,*

    a. *provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and*

    b. *compare projected stock status to existing rebuilding or recovery schedules, as appropriate.*

This ToR was completed, and the method used is appropriate for the swept-area assessment data providing the starting population and F vector. The projections do not provide a quantitative basis for advice on management.

Projections were made over a 20-year period. The results for the first decade will be influenced almost entirely by the current population size and structure, as there has been an extended period of negligible recruitment. The projections may be over-optimistic as the starting biomass (106,000t) is much higher than for earlier years because of the anomalously high survey estimate for 2006.

8. *Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.*

Nine of the eleven recommendations were completed or in progress. The two recommendations on which no progress was made were to conduct experimental work on NEFSC trawl survey gear performance, focusing on video work to study herding, and to investigate the distribution of spiny dogfish beyond the depth range of the current NEFSC surveys. The first of these remains a valid recommendation. The second recommendation may be addressed with the new research vessel and gear in coming years. Data may also be available from the monkfish surveys, which were not presented to SARC-43.

Black Sea Bass

Both reviewers considered that this assessment did not provide a credible basis for evaluating stock status in relation to BRPs. The assessment depends heavily on groundfish surveys that are not designed for this species and there were indications that catch rates were influenced by a few large tows. It was also felt that the biological reference points were not established on a sound basis. There were inconsistencies in the tagging data analysis results that undermine its validity as a means of estimating fishing mortality. However, the tagging experiments provide important information on stock movements and further analysis of the data is desirable.

1. *Characterize the commercial and recreational catch including landings and discards.*

This ToR was completed. The time-series of commercial and recreational landings were updated to include 2005 data, and a breakdown was given by gear type.

Discard rates in the commercial fishery appear low (3 – 13% from 1997 to 2005) but there are not adequate length composition data for this component. Discarding in the commercial fishery is likely to be affected by high-grading in response to quota limits. Length data for recreational discards were available only for 2005, when an MRFSS program of at-sea sampling took place. Discarding appeared to be a function of the size limit, which has changed over time. Mortality of discarded bass is poorly known but was assumed to be 15%.

Some length frequency data were available and used for an exploratory assessment using the Length Tuned Model. However, adequate length composition data are not available for bass discarded from the commercial fishery, particularly the poorly sampled pot and hook fisheries. Observer coverage is mostly for the trawl fishery but unfortunately no data on discard rates or size composition from the observer programme were presented.

2. *Describe temporal trends in abundance and size-structure based on data from NEFSC surveys. When possible, characterize the uncertainty of point estimates. Describe data from other surveys, as appropriate.*

The temporal trends in abundance and size-structure based on data from NEFSC surveys and their uncertainty were characterized. However, there was inconsistency about the best methods to represent the index values and their uncertainty.

The reviewers have commented on the mixed use of arithmetic and log transformed indices of abundance. Quite different perceptions of the stock are generated depending on the choice of scale. This is due to highly variable catches and the influence of a small number of large tows. It is inconsistent to use back-transformed log indices to characterise stock abundance when the reference points are developed using the arithmetic scale. It is also possible that the design of the NEFSC survey may miss fish in deeper water and this may be important if there are changes in stock distribution from year to year.

The confidence intervals for the survey indices were very large for the arithmetic values but less so for the logged indices. More work is required to estimate confidence intervals where catch rates are highly variable.

Results of other State surveys providing regional recruitment indices are described, but the correlation between the series is not explored before generating a combined index based on ranks, and almost no information is given on the distribution of tows, catch rates or variability in catch rates within surveys. The surveys all use different survey designs and gears.

3. *Describe migration patterns based on data from the recent tagging study.*

This ToR was completed. A clear and consistent pattern of seasonal alongshore and cross-shelf patterns of migration are evident, and the tagging programme has provided a substantial contribution to understanding of the migration patterns in this species.

4. *Estimate annual rates of fishing mortality and total mortality, based on the recent tagging study. Characterize the uncertainty of those estimates.*

Tagging data were used to estimate fishing mortality but the results were not considered to be adequate for management purposes.

Two analytical methods were used. The R/M method gave current estimates of F of 0.31-0.33 which is close to the BRP of $F_{max.}$ The working group preferred the R/M method over the Brownie method because the latter did not give credible results. However, exploration of the data shows that there is an inconsistency between the exploitation rate during the first and second years of recaptures estimated from the R/M model and this may explain the problems with the Brownie method. It appears that incomplete mixing during the first year and migration may underlie this problem, which requires further investigation.

5. *Evaluate current stock status with respect to the existing BRPs.*

This ToR was addressed. However, the reviewers question both the BRPs and the estimates of current biomass and fishing mortality.

The perception of the status of the stock relative to biomass thresholds is very sensitive to the method used to calculate the survey indices. Not only are the confidence intervals very large, meaning the current biomass is probably indistinguishable from the BRP, but calculating both current biomass and the BRP on a consistent scale (i.e always arithmetic or always logged) can lead to a divergent perceptions of current stock size relative to the BRP. The definition of the biomass threshold was not considered satisfactory. One reviewer questioned whether it was consistent with F_{max}. The other pointed out that establishing the biomass threshold as the period of low biomass from which the stock recovered is as plausible as setting the BRP to the early period of high biomass.

Given the uncertainty over growth, mortality and selectivity, the estimation of F_{max} is uncertain and there is no credible estimate of current fishing mortality with which to compare it. Hence the evaluation of status relative to fishing mortality reference points is not possible.

6. *Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.*

Estimates of precision of the recreational catches were calculated. These indicate relatively large standard errors on the 1982 and 1986 landings estimates. The results of the Length Tuned Model were not markedly affected by replacing these values with average values. However, the LTM model is not used for the assessment, and the methods used for providing management advice do not presently use fishery or recreational catch data.

7. *Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in the previous SARC-reviewed assessment*.

Recommendations related to improving the sampling of commercial and recreational catches, estimating confidence limits for recreational catches and development of a standard assessment based on a population model were completed but no progress was made on the remaining nine recommendations. The length based model investigated by SAW-43 was not successful and further development is required.

Acknowledgements

This work could not have been completed without the dedication and hard work of the assessment scientists who assisted the panel at all times. Special thanks are due to Jim Weinberg for his organisation and help before, during and after the SARC meeting. Paul Rago is especially thanked for his support both scientifically and caffeinetically.

Materials available during the review

Ocean Quahog

A1- Ocean Quahog (*Arctica islandica*) Stock Assessment

A2- Stock Assessment for Ocean Quahog in Maine Waters

A3- Ocean Quahog Assessment Summary

A4- Ocean Quahog Assessment 2003

A5- Ocean Quahog Advisory Report, 2003

A6- Gulf of Maine Ocean Quahog (*Arctica islandica*) Assessment
Completion report submitted to the Northeast Consortium

A7- Paul J. Rago, James R. Weinberg, and Christopher Weidman. A spatial model to estimate gear efficiency and animal density from depletion experiments. Canadian Journal of Fisheries and Aquatic Sciences, *in press*.

<u>PowerPoint presentations:</u>
Dredge survey pump performance
Tow criteria
Ocean Quahog assessment
Maine survey

<u>Spreadsheets:</u>
Biomass check

Spiny Dogfish

B1- Assessment of Spiny Dogfish (*Squalus acanthias*) for
2005

B2- Female Spiny Dogfish Length Tuned Model (LTM)

B3- Spiny Dogfish Assessment Summary For 2006

B4- Spiny Dogfish (*Squalus acanthias*) assessment 2003

B5- Spiny Dogfish Advisory Report, 2003

B6- Nammack, M, J. Musick and J. Colvocoresses. 1975. Life History of Spiny Dogfish off the Northeastern United States. Transactions of the American Fisheries Society 114:367-376

P.J. Rago, K.A. Sosebee, J.K.T. Brodziak, S.A. Murawski, E.D. Anderson Implications of recent increases in catches on the dynamics of Northwest Atlantic spiny dogfish (Squalus acanthias). Fisheries Research 39 (1998) 165-181

PowerPoint presentations:
Discard length frequencies
LTM results
Dogfish assessment 1
Dogfish assessment 2
Constrained selectivity

Spreadsheets:
Selectivity results
MRFSS data

Black Sea Bass

C1-Assessment of the Northern Stock of Black Sea Bass

C2- Appendix to Black Sea Bass Assessment. Black Sea Bass Length Tuned Model (LTM)

C3- Black Sea Bass Assessment Summary, 2006

C4- Assessment of the Northern Stock of Black Sea Bass, 2004

C5- Black Sea Bass Assessment Summary, 2004

C6- Pollock, K, J. Hoenig and C. Jones (1991). Surveys for Biological Analysis: Estimation of fishing and natural mortality when a tagging study is combined with a creel survey or port sampling. American Fisheries Society Symposium **12:**423-434.

C7- Pollock, K. (1991). Modeling capture, recapture and removal statistics for estimation of demographic parameters of fish and wildlife populations: past, present and future. Journal of the American statistical association, **86**:225-238.

PowerPoint presentations:
Juvenile survey distributions
Tagged fish movements
Seasonal recaptures
LTM results

Spreadsheets:
Brownie model

Deep Sea Red Crab

D1- Assessment of Deep Sea Red Crab, *Chaceon quinquedens*

D2 - Assessment Summary for Deep Sea Red Crab, *Chaceon quinquedens*

D3 – R. Wigley, Theroux, R and Murray, H. Deep-sea Red Crab (*Geryon quinquedens*) Survey off Northeastern United States. MFR Paper 1154.

D4- Serchuck, F. 1977. Assessment of Red Crab (*Geryon quinquedens*) populations in the Northwest Atlantic. NEFSC Lab ref # 77-23.

PowerPoint presentations:
Red crab assessment

Spreadsheets:
Fishable biomass estimates by year

Annex I: Review report by Mike Armstrong

43rd NORTHEAST REGIONAL STOCK ASSESSMENT REVIEW COMMITTEE (SARC-43)

Report on the 2006 assessments of black sea bass (*Centropritis striata*), spiny dogfish (*Squalus acanthias*), ocean quahog clams (*Arctica islandica*) and deep sea red crab (*Chaceon quinquedens*) in the Northeast United States

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Mike Armstrong

Prepared for

University of Miami

Center for Independent Experts

The Centre for Fisheries and Aquaculture Science
Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk NR33 0HT
England, United Kingdom

Phone: +44 1502 524362
Email: mike.armstrong@cefas.co.uk
www.cefas.co.uk

Contents

1. Background

This report provides an independent review of the assessments of black sea bass (*Centropritis striata*), spiny dogfish (*Squalus acanthias*), ocean quahog clams (*Arctica islandica*) and deep sea red crab (*Chaceon quinquedens*) presented at the 43rd Northeast Regional Stock Assessment Review Committee meeting. The author was provided with web access to draft stock assessment reports and background material, and participated in the 43rd Northeast regional Stock Assessment Review Committee (SARC-43) meeting to review the assessments carried out at the Stock Assessment Workshops (SAW-43).

2. Review activities

The panel convened at the Woods Hole Laboratory of the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts, from June 6-12, 2006. The Committee comprised a chair and two panelists.

For each stock, a formal presentation of the SAW results was given by the lead assessors, and specific issues were discussed. The assessors returned, if required, for further discussion and clarification of how the SAW Terms of Reference were addressed.

Panel members were then required to prepare an independent report indicating for each Term of Reference of the relevant SAW: i) whether the work that was presented is acceptable based on scientific criteria (e.g. consider whether the data were adequate and used properly, the analyses and models were carried out correctly, and whether the conclusions are correct/reasonable); and ii) whether the work provides a scientifically credible basis for developing fishery management advice.

In addition to addressing the ToRs for each stock assessment, this report also includes comments on additional questions that were not in the Terms of Reference but that are directly related to the assessments. These are given in a separate section at the end of the report for each assessment.

The SARC chair and panelists read both of the panelists independent reports, and a consensus report was drawn up.

4. Acknowledgements

I would like to thank all the stock assessment teams at SARC for their informative presentations of the SAW results and for providing helpful response to the SARC’s questions. Many thanks also to staff at the Woods Hole Laboratory and particularly to Jim Weinberg for their hospitality and help throughout the meeting. Many thanks also to the other members of SARC for productive discussions on the assessments.

4. **Assessment of deep-sea red crab** (Invertebrate Working group)

4.1 Overview

My overall conclusion for this stock is that the assessment as presented has a number of deficiencies in data, analysis and knowledge of some important processes, but the overall conclusions on biomass and fishing mortality in 2003-2005, and changes in abundance and population structure since 1974, provide a scientifically credible basis for developing fishery management advice. There is no doubt that fishing mortality is currently low, but there is currently no knowledge of what would constitute an appropriate target or threshold F. The SAW had insufficient information to evaluate the implications of the current estimate of F or any additional F associated with unaccounted-for discard mortality.

The last assessment of this stock was provided by Serchuk (1977), and was based primarily on the camera-survey results for 1974 provided by Wigley et al. (1975). The 43rd SAW assessment of the stock analysed equivalent results from four camera and trawl surveys carried out during 2003-2005. The surveys provided an excellent example of effective industry-science collaboration through the Northeast Fisheries Consortium, and represent a major advance in understanding of red crab distribution, abundance and population structure. In addition, commercial fishery data were compiled and used for estimating fishing mortality from the ratio of landings to camera-survey biomass estimates for the fishable stock. Supporting data on by-catch and size composition of crabs in ongoing trawl surveys were also presented. The main issues arising from the assessment and discussions at SARC were:

- Comparability of survey data from 1974 and 2003-2005;
- Implications of changes in size structure between the two periods;
- Estimation of F, and implications of the estimates;
- Discards and discard mortality;
- Form of summary advice to be presented.

The extent to which the assessment programme has addressed each of the Terms of Reference for the SAW is evaluated below.

4.2 Characterize the commercial and recreational catch including landings and discards.

This ToR was completed using appropriate methods. Different aspects of the ToR are evaluated below.

4.2.1 *Landings and fishing patterns*

Landings estimates from dealer/weighout reports from 1982 onwards were provided by gear type, and landings and discards estimates from VTR logbooks from 1994 onwards were presented. The spatial patterns in fishing activities were clearly shown. Size compositions of landed crabs were provided based on port sampling of 3-20 trips per year from 2001 onwards, and additional size compositions of crabs measured at sea during 2004-2005 were presented. There is no recreational catch of red crabs.

4.2.2 *Discards*

Data from VTR log books and some at-sea sampling indicate very variable discard rates, which may not be reliable. However, values for 2004 and 2005 indicate up to 30% of the catch is discarded. A large fraction of this is probably females, which are not permitted to be landed. Uncertainty over the survival rate of discards was a concern raised on a number of occasions during the SARC meeting. Tagging studies show that released crabs do survive, but the rate is unknown. Currently, some research is underway on survival of discards that may provide further insights.

4.2.3. *Size composition and fishery selection*

The landings length frequency data were used together with trawl survey length frequencies in 2004-2005 to estimate a fishery selection pattern for male crabs. The method for estimating fishery selection assumes the survey trawls provide unbiased information on crab size structure, and does not take into account the variance in the length composition data. Hence, there is a missing component of variance in the fishable biomass estimates from the camera surveys, although this may be relatively small.

4.2.4. *Landings per unit effort*

Data on landings per unit effort from 2001 were given based on data considered more reliable than for earlier years, and a GLM model was also fitted to these data, giving significant year, quarter, vessel, area and area-quarter interactions. The series is too short to draw any meaningful conclusions but do not indicate any major short-term trends in abundance. Longer-term LPUE data were also presented. Although these were difficult to interpret because of incomplete reporting and changes in vessels and fishing behaviour, there was again no compelling evidence for major changes in catch rate over time.

4.3 Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

4.3.1 *Overview*

This ToR was completed with variable success. The SAW-43 assessment addressed the ToR using the results of the camera surveys. Estimates of fishing mortality, total stock biomass, fishable biomass, and biomass of 114mm+ crabs for combined 2003-2005 camera/trawl survey data were presented. Estimates of precision were given based on the variation between the individual survey estimates rather than from the sources of variation within surveys. Equivalent biomass estimates for 1974 were also presented by re-working the Wigley *et al* (1975) data. Fishable biomass was calculated using the fishery selection curves for 2004-2005. Spawning biomass estimates were not presented as the assessors considered they had inadequate information on maturity ogives, but were requested by the SARC. Comments are given below on various aspects of the survey estimates.

4.3.1 *Survey design*

The 2003-2005 camera surveys appeared technically well executed. The survey design did have some limitations for the purpose of providing statistically robust estimates of absolute abundance. The stratification scheme followed the 1974 survey but sampling was not fully randomized within strata. A number of locations were fixed in an attempt to provide comparability with the 1974 survey, with some additional random tows. The tows took place along transects running across depth contours, so the basic sampling elements were effectively transects spanning several depth strata. This means that the samples in the area/depth strata are not independent if there are similar along-shore variations in abundance within depth strata. Figure D5.2 in the SAW assessment report provided to the meeting indicates relatively low sampling within areas A, C and D in 2003, and sampling of only the western limit of area D each year despite area D representing a quarter of the full survey area. There is also a narrow strip of crab habitat to the south of the survey area towards Cape Hatteras not included in the survey.

Although the survey design is likely to cause some bias in estimates of population abundance, and potentially reduce the variation between surveys by having an element of fixed stations, the biases are probably insufficient to invalidate the general conclusions on biomass, fishing mortality and population structure given by the SAW. However, if the surveys were to be repeated in future, more attention to survey design (c.f. the ocean quahog surveys) would be warranted to allow unbiased estimates of abundance and to allow all aspects of survey variance to be properly evaluated.

4.3.2 *Comparability between 1974 and 2003-2005 camera surveys*

The 2003-2005 surveys used a completely different camera and sled compared with the 1974 survey. The video camera image in the 2003-05 surveys covered an effective area of $6.6m^2$ compared with $31.8m^2$ for the film camera used in 1974. The potential differences in efficiency of the two methods could not be quantified. Inferences drawn were that 1) both rigs probably provide similar detection of large crabs recorded in the frames; 2) the 1974 survey may have had reduced detection of small crabs, particularly at the edge of the frames, and 3) some avoidance of the sled may have been occurring and may have been relatively more of a problem for the smaller sled used in 2003-2005. Avoidance was indicated by differences in counts between the leading and trailing sectors of the video frames. Taken together, these inferences suggest that the density estimates from the 1974 and 2003-2005 surveys may not be compatible. On balance, the differences may not be substantial, but without a direct comparison of the two methods, the magnitude is unknown. Small differences in the method for raising density estimates to biomass by population component between 1974 and 2003-2005 were shown to have only a small influence on biomass estimates.

4.3.3 *Analysis methods*

Estimates of abundance from the four surveys were averaged to provide a single value for 2003-2005. The method appeared to involve averaging the individual area/depth stratum estimates across surveys. As a result, some strata may have four estimates, and others less than four. It was not clear how the results could be influenced by individual surveys, some of which (e.g. June 2003) had poorer coverage than others. The SARC panel asked the assessors to show individual survey estimates by stratum, as well as the length frequency data by stratum and survey, to see how much variation was present. The panel also asked for total biomass estimates and the derived fishing mortality estimates for each survey on its own.

This required more extensive filling in of missing survey strata, particularly for June 2003. Filling-in was done using average density by depth band across the surrounding along-shore areas. The size composition data were very variable, due to relatively small numbers of trawls per stratum, but with the exception of June 2003, when sampling levels were lower than in subsequent surveys, the fishable biomass and F estimates from the individual surveys were very similar:

Estimate	June 03	Aug 03	2004	2005	Mean	CV of mean
Fishable biomass	27,573	37,844	40,868	38,712	36,249	8%
Fishing mortality	0.070	0.051	0.050	0.052	0.056	8%

The combined-survey biomass and F estimates provided by SAW were almost identical to the average of the four independent survey estimates given above. However, the CV of the mean given for the SAW combined estimate was 15%, which is equivalent to the CV of the estimates given in the text table above rather than the CV of the mean shown in the table.

Without valid estimates of individual survey precision, there would be no basis for an inverse-variance type weighting to reduce the influence of the more poorly sampled June 2003 survey in the average. The true precision of the mean estimates of biomass and F from the surveys is likely to be underestimated by an unknown amount. For example, the individual surveys could have poor precision, but with only four surveys there could be a chance occurrence of four similar estimates implying high precision.

4.3.4 *Changes in population structure*

Based on trawl catches using almost identical gear and fishing methods, the population structure in 2003-2005 appears to have a much smaller fraction of crabs > 114mm carapace width (mostly males), and an increased abundance of smaller crabs (male and female in about equal numbers) in the 55-80mm range compared with the 1974 survey. Data by depth band show the depletion of large males to be a particular feature of the shallower depth strata where most commercial fishing takes place. The increase in density of the smaller crabs is most evident in the deeper strata. Data from other trawl surveys covering all or part of the crab habitat support the findings of the camera/trawl surveys.

It is likely that the observed changes in population structure are real, but the causes can't be explained as yet by any form of analytical analysis. During the meeting it was hypothesized that fishing has depleted the abundance of large males, and that the stock may have experienced improved recruitment of smaller crabs compared to the stock in the 1970s.

4.4 Either update or re-estimate biological reference points (BRPs), as appropriate.

Lack of data on growth, longevity and trends in abundance precluded an up-date or re-estimate of BRPs.

A reference point for over-fishing was established when the current FMP was developed. An MSY value of 2,494t was calculated based on the formula MSY = $0.5.M.B_0$, and assuming that the biomass of 100mm+ male crabs in 1974 was equivalent to B_0. Natural mortality (M) was assumed to be 0.2.

The use of $0.5.M.B_0$ as an MSY reference point is unlikely to be appropriate as M is unknown, the shape of the production curve is unknown, patterns of variability in recruitment are unknown, and it is not clear how production would relate to biomass of males. New analyses are required to provide more appropriate reference points for management, based on knowledge of the biology and dynamics of this stock as it becomes available.

4.5. Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

In the absence of any revised BRPs it is possible only to say that recent landings are below the existing MSY figure.

4.6 Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

The SAW made a series of research recommendations related to commercial fishery data, fishery-independent data, biological data and assessment methods. They recommended an evaluation of a size-structured and sex-specific stock assessment model compatible with the available data, but did not suggest a particular structure for such a model. Some modeling work had been carried out prior to the SARC meeting but the results were not suitable to be presented.

4.7. If possible,

c. provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and

d. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

No projections were carried out because of a lack of data on red crab growth, recruitment and natural mortality.

4.8. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

There were no previous SARC/Working Group research recommendations.

4.9 Discussion items falling outside the Terms of Reference

Most of the discussion centered on topics relevant to the ToRs. Additional topics included discussion of poorly-understood aspects of the biology of red crabs. A possibility was raised that depletion of large male red crabs could have led to improved survival of small crabs due to reduced cannibalism or aggression. Changes in size structure could also affect mating success given the need for males to mate with females smaller than themselves.

4.10 Research recommendations

The SAW report contains a range of research recommendations, all of which would be useful. My own recommendations for further research reflect some of the SAW recommendations:

- Improve the knowledge of the biology of deep sea red crabs to an extent allowing a range of plausible models of growth, mortality and recruitment processes to be set up. Use these to explore the possible boundaries for sustainable exploitation and hence to develop more useful biological reference points.

- If camera surveys will not be repeated, other indicators of stock status should be monitored. LPUE series including GLM analysis should be developed further, and factors affecting stability of catchability evaluated. Participation of fishermen in a scheme to record numbers and sizes of ovigerous females could also provide useful information.

- If camera/trawl surveys are to be repeated in the future, the surveys should be designed to allow unbiased estimates of abundance and variance. The efficiency of the camera system for estimating crab density should be quantified. More reliable techniques for collecting trawl samples should be developed, for example including bottom contact sensors and other net monitoring systems to ensure the net is on the seabed throughout the tow, to ensure all relevant sizes of crabs are equally vulnerable to capture and to allow swept-area estimates to complement the camera sled estimates.

5. Assessment of ocean quahog (text omitted)

6. Assessment of black sea bass (Southern Demersal Working Group)

6.1 Overview

This assessment covers the stock of black sea bass off the Northeast coast of the USA between Cape Hatteras and the Gulf of Maine. The stock was last assessed in 2004 (SAW-39).

The SAW-43 assessment is based on fishing mortality estimates from tagging studies and biomass trends from a single trawl survey. The assessment of current stock status in relation to reference points is not acceptable based on scientific criteria and does not provide a scientifically credible basis for developing fishery management advice.

The tagging study has been extremely successful in demonstrating seasonal migration patterns, and represents a major and important advance in knowledge of population biology. However the indications of strong site fidelity suggest that spatially separated groups of tagged individuals could have different exploitation histories. The current method of combining the data without consideration of spatial difference in abundance and fishing mortality could therefore lead to biased estimates of overall fishing mortality. Further analysis with a spatial component is needed before the results can be considered sufficiently accurate for evaluating against biological reference points.

The NEFSC survey is not designed specifically for black bass, and the confidence limits around the arithmetic mean indices used for providing management advice are very wide. This indicates highly variable catch rates and a tendency for the indices to be heavily skewed by large individual catches. Furthermore, strong recruitment apparent in surveys during 2000-2002 has not produced an expected increase in the adult biomass indices. The surveys may contain useful information on stock trends for direct use in management or for tuning catch-based analytical models, but the way the data are currently being used is inappropriate and needs to be re-evaluated.

A length-based analytical assessment was investigated, but provided a poor fit to the survey data and was very sensitive to the input growth parameters. Further development and testing of the model is needed.

The extent to which the SAW-43 addressed its Terms of Reference is evaluated in the following sections.

6.2 Characterize the commercial and recreational catch including landings and discards.

This ToR was completed using appropriate methods. The time-series of commercial and recreational landings were updated to include 2005 data, and a breakdown was given by gear type.

Discarding in the commercial fishery was evaluated from VTR logbook data, as observer trips do not adequately cover the pot or hook and line trips constituting a large part of the landings. Discard rates in the commercial fishery appear low (3 – 13% from 1997 to 2005). The increase in discard rate over the 2000-2003 period is consistent with the apparent increase in recruitment shown by the trawl surveys.

A previous SARC request to evaluate the precision of the survey estimates of recreational catch and discards was addressed. Confidence limits were tight except for 1982 and 1986 landings when there were large estimates of recreational landings that the assessment team considered suspect.

Sampling rates for estimating the length composition of the fishery landings have increased substantially since 2003. The length frequency data were used for an exploratory assessment using the Length Tuned Model, which did not produce satisfactory results (see later). Adequate length composition data are not available for bass discarded from the commercial fishery, particularly the poorly sampled pot and hook fisheries. Observer coverage is mostly for the trawl fishery but unfortunately no data on discard rates or size composition from the observer programme were presented. Discarding in the commercial fishery will also be a function of high-grading in response to quota limits.

Data for recreational discards were available only for 2005, when an MRFSS program of at-sea sampling took place. Discarding appeared to be a function of the size limit, which has changed over time.

Mortality of discarded bass is poorly known. Estimates of 5% from cage experiments in shallow water are likely to be much lower than is occurring in the commercial fishery or in recreational catches in deeper water where swimbladder expansion is a problem or where the fish can become damaged by the fishing operation. The assessment team suggested an arbitrary value of 15% for the deeper water fisheries, but there is effectively no scientifically valid estimate and discard mortality must be considered to be effectively unknown pending further studies.

6.3 Describe temporal trends in abundance and size-structure based on data from NEFSC surveys. When possible, characterize the uncertainty of point estimates. Describe data from other surveys, as appropriate.

This ToR was completed using the same approach as in the 2004 assessment reviewed by SARC-39. The NEFSC spring survey forms the basis for describing trends in abundance in this stock and for evaluating current biomass against the defined biomass reference point. There are clearly problems with this and other surveys with regard to highly variable catch rates between tows, and the allocation of tows between strata is not optimum as the surveys are designed for a range of species. The assessment team has chosen to use geometric mean catch rates to reduce the effect of large catches on temporal trends, but the management plan uses arithmetic means for evaluating current biomass (3-year mean) against the biomass threshold (mean SSB index for 1997-1979). A more detailed investigation of the robustness of the survey trends is warranted, together with a re-evaluation of how the BRP and the evaluation of current status against the BRP should be defined.

Future assessments should fully document the variation in catch rates and the contribution of large sets to the biomass indices. Methods of handling highly-skewed catch rate distributions should be considered rather than the simple expedient of taking logarithms, and more realistic confidence intervals for the survey indices should be developed.

Significant catch-rates of bass are recorded along the offshore boundary of the NEFSC survey in winter and spring, leading to a potential for year-effects due to variable extension of the stock into deeper water. The assessment team commented that other surveys extending into deeper water do not seem to catch significant numbers of bass in the deeper water, so the bias may be small. The new NMFS research vessel (RV *Henry B. Bigelow*) will use a new net design more suitable for deeper water, and improved information on the offshore limits of the stock may be forthcoming in future.

The winter survey provides a shorter time series (1992 onwards). The fall survey is not considered appropriate due to the aggregation of the fish around structures at this time of year.

The Massachusetts Division of Marine Fisheries spring bottom trawl survey provides another long-term series of SSB and recruitment indices. The assessment report doesn’t provide any information on the design and coverage of the survey or the variability in catch rates within surveys. The trends differ markedly from the NEFSC spring survey in terms of the timing of recruitment and biomass peaks, but these differences are difficult to evaluate on the basis of the information available in this year’s report or in the 2004 report.

Results of other State surveys providing regional recruitment indices are documented in the assessment report, but the correlation between the series is not explored before generating a combined index based on ranks, and almost no information is given on the distribution of tows, catch rates or variability in catch rates within surveys. The surveys all use different survey designs and gears.

6.4 Describe migration patterns based on data from the recent tagging study.

This ToR was completed. A clear and consistent pattern of seasonal alongshore and cross-shelf patterns of migration is evident, and the tagging programme has provided a substantial contribution to understanding of the migration patterns in this species.

6.5. Estimate annual rates of fishing mortality and total mortality, based on the recent tagging study. Characterize the uncertainty of those estimates.

6.5.1 *Analysis of tagging data*

The base-line R/M model used for estimation of exploitation rate was the same as the model accepted by the previous SARC. The additional years of tagging data provide a consistent pattern of tag returns, and the high-reward tagging scheme gave consistent estimates of tag return rates between 55% and 69%. Evidence was given in the report for some non-reporting of the high reward tags, so the estimated reporting rates may have a small but unquantifiable bias. Estimates of fishing mortality for the four tag release periods, based on recaptures in the year following release, ranged from 0.20 – 0.33. The estimates from the first two experiments given in the 2004 SAW assessment (0.21 – 0.26) were below the F_{max} reference point of 0.33. The results from the second two experiments (F = 0.31 – 0.33) indicate the fishery is now operating close to F_{max}. Hence, it is important that the scientific validity of the tag estimates of F is well established.

The seasonal patterns of tag recovery show that fish released at different sites along the coast migrate to a common offshore area where thorough mixing of all components takes place. This area is mainly in the southern region, resulting in relatively long along-shore movements of fish tagged in the north and inshore-offshore movements of fish tagged in the south. Fishing mortality during winter will therefore come mainly from the offshore fishery. From spring onwards the fish exhibit a return migration to the same general area where they were tagged, and in the summer and fall there is strong site fidelity with little mixing of fish from the different release sites. Black bass resident in different parts of the Northeast coast will therefore experience site-specific rates of fishing mortality during each summer-fall period after release. The R/M tagging model used by the SAW does not account for these well-defined migration patterns. If numbers of releases are not proportional to abundance in areas with different exploitation rates, and the tagged fish have site fidelity, estimates of F for the whole population could be biased. The bias will depend on the proportion of F that is generated by the offshore fishery during winter when the fish from all areas are well mixed, and the regional variability in F when the fish are inshore in summer and fall.

The previous SARC recommended a more sophisticated analytical model such as the Brownie with a migration extension. The SAW-43 investigated a number of configurations of a seasonal Brownie model, but did not include any migration extension. The Brownie model did not appear very robust, and there were large differences between observed and expected recaptures. Hence the SAW proposed continued use of the R/M method. However for reasons given above there is also a potential bias in the R/M method due to spatial dynamics of the stock, and the methods used by SAW require simulation testing to evaluate potential bias. This could be examined using a simulated population with migration patterns given by the tagging study, population distribution as given by surveys, spatial patterns of catch in the different fisheries, and different tag release patterns including the actual tagging programme.

6.5.2 *Length tuned model*

The length tuned model also used for spiny dogfish this year was investigated for black sea bass. Recruitment indices from the NEFSC winter, spring and fall surveys were used, and the model was tuned to the 30cm+ part of the length frequencies of the fishery catch and the 22cm+ fish in the winter and spring NEFSC surveys. The absence of discards from the fishery data could be problematic as there is evidence for increased discard rates during the recent period of elevated recruitment indicated by surveys. Time-varying partial recruitment ogives were imposed, to reflect changes in minimum landing size.

The model results were very sensitive to different assumptions regarding growth, and could not reconcile the survey indices of recruitment with the apparent recent trends in 22cm+ abundance in the survey. None of the model runs are suitable for providing credible management advice, but further development of length-based methods are encouraged. Ageing of a sufficient number of otoliths or scales from the stored collection is also encouraged to help establish the growth patterns and their stability over time. Concerns over the error structure of the survey data due to highly variable catch rates within surveys (see 6.6 below) are also relevant to how the surveys are used in the model.

The robustness of the LTM model or any further development of it should be examined for black seabass using simulation testing. This would require setting up “true” population numbers at length from which “assessment data” are drawn under a range of assumptions regarding completeness, error levels and structure.

6.6. Evaluate current stock status with respect to the existing BRPs.

6.6.1 *Fishing mortality reference point*

The new R/M tagging estimates of F and the NEFSC spring survey indices for 2004-2006 were used as required to evaluate current stock status against the fishing mortality and biomass BRPs.

The R/M tagging model point estimates of F for fall 2004-2005 (mean F = 0.32) is marginally below the F_{max} of 0.33, but the probability of $F > F_{max}$ is likely to be between 40-50% based on the parametric bootstrap estimates. The possibility that the tagging estimates of F could be biased due to spatial dynamics of the stock is discussed earlier.

6.6.2. *Biomass reference point*

There are concerns over the appropriateness and robustness of the biomass reference point and the data used to evaluate stock status relative to it, and these are discussed below.

The 3-year running mean index of exploitable biomass (fish $\geq$ 22cm) from the Spring survey in 2004-2006 (0.80 kg/tow) is below the biomass threshold proxy of 0.98 kg/tow. On this basis, the stock is classified as overfished. However, both these estimates are based on arithmetic mean catch rates. Table C7a in the 2006 assessment report provided to SARC-43 gives biomass indices for both the arithmetic means and the geometric means. Although the point estimate of B_{04-06} is almost 20% below B_{97-99} using arithmetic means, the 95% confidence limits are extremely wide, falling below zero in two out of the three years in each period. The CV inferred for each of the 1977 – 1979 estimates is of the order of 1.0, indicating that the survey indices were probably dominated by a few very large individual catches each year. The CVs for the 2004-2006 indices are lower, of the order of 0.5 or below, but still very large.

In contrast to the arithmetic mean catch rates, the $B_{04\text{-}06}$ based on geometric means is more that double the $B_{97\text{-}99}$ value. The lower 95% confidence limits for the GM indices in each of the years 2004-2006 exceed the upper 95% limits for each of the 1977 – 1979 indices. Thus, the perception of the status of the stock relative to biomass thresholds is very sensitive to the method used to calculate the survey indices.

The choice of mean biomass index for 1997-99 as a threshold was presumably because this represented the highest value during the period of elevated biomass during the 1990s. However it is not clear why this is used as a threshold, and if it is in any way compatible with the average biomass expected by fishing at or near the F_{max} threshold. The GM indices also show a period of elevated biomass in the 1970s, but the temporal pattern is different, with a peak 3-year running mean of 0.37 kg/tow occurring over the period 1974-1976 rather than 1997-1999. The 3-year mean for 2004-2006 GM indices is 0.33 kg/tow. Hence, using the same philosophy for setting the BRP as implied by the present management procedure, the current stock would be considered below the threshold as $B_{04\text{-}06}$ is below $B_{74\text{-}76}$, the peak 3-year mean biomass during the 1970s. The procedure is nonetheless affected by the methods of analyzing the survey data and the difficulty in evaluating the biomass trends because of the very large variability in catch rates between sets.

6.7. Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

Estimates of precision of the recreational catches were calculated and are given in Table C19 of the assessment report provided to SARC-43. These indicate relatively large standard errors on the 1982 and 1986 landings estimates. The results of the Length Tuned Model were not markedly affected by replacing these values with average values. However, the LTM model is not used for the assessment, and the methods for providing management advice do not presently use fishery or recreational catch data.

6.8. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in the previous SARC-reviewed assessment.

The 2006 SAW stock assessment report provided to SARC-43 lists the research recommendations from the previous SARC and the extent to which these have been addressed. Recommendations related to improving the sampling of commercial and recreational catches, estimating confidence limits for recreational catches and development of a standard assessment based on a population model were completed but no progress was made on the remaining nine recommendations. The length based model investigated by SAW-43 was not successful and further development is required.

6.9. Further research recommendations

The SAW-43 made a number of recommendations for further research:

- If a new analytical assessment is available, update BRPs as part of the assessment;

- Continue work on length based or other analytical model;
- Continue work on defining migration pathways and identifying migration groups for use in analyzing tagging data;
- Continue funding for management of tag recoveries and outreach programmes;
- Examination of population structure using genetics.

The SAW noted that the first two recommendations were contingent on ageing the backlog of age structures in storage and developing reliable estimates of fishery discards.

Given the termination of the tagging programme and the difficulties in interpreting the survey data, the recommendation to complete the ageing of the backlog of otoliths or scales would appear critical to allow either some form of age based assessment or to condition a length-based assessment.

I would further recommend:

- The development of a simulation framework to examine the robustness of tag-based mortality estimates for this stock given present knowledge of the population, fishery and migration patterns;
- A thorough review of the NEFSC and other survey data to evaluate the statistical properties of the catch-rates per tow, and to develop more robust abundance trends for assessment and management;

6.10 Discussion topics outside of the Terms of Reference

There were no specific discussion topics that fell clearly outside of the Terms of Reference.

7.0 Assessment of Spiny dogfish - (Southern Demersal Working Group)

7.1 Overview

This stock was last assessed by SAW-37 in 2003. The data and analysis for the SAW-43 assessment in 2006 provide a consistent indication of a substantial decline in mean length and biomass of 80+cm female dogfish during the 1990s. This result is consistent with the large increase in fishery catches during the 1990s. The data also clearly show an extended recent period of very poor recruitment. These aspects of the assessment are scientifically valid and provide a credible basis for advice for management. The current biomass and fishing mortality estimates are however strongly influenced by a very large survey estimate in 2006. This is unlikely to be reliable and probably gives an overoptimistic view of the current state of the stock and an overoptimistic view of future stock development under status quo fishing mortality. Major issues addressed at SARC-43 included:

- Estimation of discards and appropriateness of discard mortality rates;
- Interpreting the large reduction in mean length of females in recent years;
- Fishery selectivity and changes over time;
- Interpreting highly variable survey catch rates including the large 2006 estimate;
- Lack of recruitment in recent years and reasons for this;
- Biological reference points including the relationship between F reference points and fishery selectivity

The assessment team carried out a large number of different analyses, and was very thorough in evaluating the characteristics of the survey catches. A useful exploration of the Length Tuned Model was also carried out, although the model needs further development and testing for this stock before it can be used to provide management advice.

The volume of analysis and results made it quite difficult to evaluate the SAW report in places, and future reports of this complexity should be structured in a more logical fashion with the key assessment data and results clearly highlighted.

Comments are given below in relation to the individual terms of reference.

7.2 Characterize the commercial and recreational catch including landings and discards.

This ToR was completed using valid scientific approaches, and the time series of fishery landings since the 1980s is likely to be a sufficiently accurate reflection of historic values for use in the assessment modeling. The estimation of recreational catches uses a valid survey-based approach. The presentation of fishery and recreational catches in the report is quite voluminous, and it would be useful to have a table summarizing the landings and associated discards estimates for each fleet that are used in the assessment, and a second table with the discards reduced according to the assumed discard mortality. This would allow the relative importance of the various components to be evaluated as well as the potential range in total removals.

The method of expanding observer records of discards to give an estimate of discards for the total fleet was altered in the current assessment to use the ratio of discards to total retained catch of all species. The dogfish discards were positively correlated with total species landings. Although this method is potentially more robust than the procedure adopted by the previous SAW, it should nonetheless be tested. One procedure could be to use the set of observed trips as if it was a complete census, and to re-estimate the total discards from random sub-sets of trips.

The mortality of discarded dogfish remains a significant source of uncertainty in the assessment. There are no direct estimates for dogfish discarded under all the different conditions of the different fisheries, and the discard mortality must be considered as unknown. The figures for survival of discards given in the report are highly uncertain, and it would be better to give assessment results for a plausible range of discard survival, so that worst-case scenarios can be evaluated against BRPs. This would require the BRPs to reflect the same selection curves as for the fishery with a given discard mortality pattern.

Discard quantities and their size composition in the 1980s had to be imputed from later estimates and are therefore inaccurate and contain no information on population dynamics.

7.3 Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

7.3.1 *Baseline methods used for fishery management*

Stochastic swept area method

This has been the baseline method for providing information on stock trends and fishing mortality for comparison with BRPs. The method was updated this year to include uncertainty in recreational catch, and discards by gear type.

The method is in principle scientifically valid for generating trends in biomass and fishing mortality and the uncertainty in these, but there are some issues with the use of the surveys to estimate absolute biomass or a “minimum” biomass for spiny dogfish. The main issues are the effective trawl scaling factor or “footprint”, and the fraction of the stock occurring in the survey area. A major additional problem with the survey is the large variability in estimates from survey to survey due to the influence of small numbers of very large catches.

The fall survey has a variable bias due to occurrence of dogfish in Canadian waters. It is assumed that the spring survey is less affected by migration, but distribution maps show catch rates out to the offshore boundary of the survey and there may be some underestimation due to dogfish extending into deeper water.

The trawl scaling factor is critical for swept-area estimates of biomass and hence for fishing mortality estimates based on ratio of fishery removals to swept-area biomass. It depends upon a complex interaction of fish behaviour and distribution, reaction of fish to the different parts of the trawl gear, and even the passage of the ship overhead. Spiny dogfish occur in packs, and as their diet includes pelagic species such as herring they may presumably occur off-bottom at times. Herding by the trawl warps, doors and bridles probably occurs. Area swept by trawl doors will probably vary by depth (greater spread in deeper water), which could result in changes in catchability if the fish distribution shifts to shallower water, as appears to have happened since the late 1980s.

Evidence that the winter NEFSC survey gives 3-5 times higher catch rates than the spring and fall survey is relevant, as the winter survey uses a different type of trawl without the large rock-hopper rollers fitted to the Yankee 36 trawl used in the spring survey. Unless this trawl has 3-5 times greater spread, this suggests some escapement under the footrope or other avoidance patterns differing between gears and seasons.

These observations suggest that the trawl scaling factor should be treated as being subject to some uncertainty, and hence that any fishing mortality estimates from ratios of fishery catch to survey biomass estimates must also be subject to an unknown bias. Note that the Length Tuned Model gives much lower biomass estimates than given directly by the survey, with correspondingly higher F estimates over much of the series.

The assessment team attempted to validate the trawl scaling factor estimates using a mass balance model and a modified Collie-Sissenwine model (see 7.3.2 below). The estimates of population growth (G-M) are confounded with the trawl scaling factor, and therefore the estimates using the standard trawl footprint of 0.01n.mile^2 had to be compared with empirical estimates from the length frequency distributions. This only worked for smoothed survey data, for which the C-S model estimates of (G-M) of -0.04 to -0.06 were below the empirical values. This implies that the survey estimates are too high (trawl footprint too small), which is in line with the LTM estimates of biomass.

Of greater concern is the effect of sporadic very large catches on the survey index. Tows with catch rates > 1000 kg per tow make up about 1% of the tows but yield about half the total survey catch. Such catches may also have a narrow length range or be mainly of one sex. As a result of this variability, the stochastic model for estimating biomass and F using the survey is based on 3-year running means. Outlying survey indices, such as in spring 2006 (particularly for large females), are expected given the nature of the data, and may have undue leverage in any assessments.

The procedure for applying fishery selectivity curves to the survey length frequency distributions to estimate exploitable biomass, leads to annual estimates of fishing mortality that relate to the fully exploited (asymptotic) F. Given the very large apparent change in the shape of the selection curves, this means that the annual F estimates do not consistently reflect what fraction of the stock as a whole is being removed by fishing each year. If there were two years with the same asymptotic F, but in one year the L50 was well below the mean length in the catch, and in the other year it was well above the mean length, the difference in F estimates would not reflect the very large change in the fraction of the fish in the population being removed by fishing. Presentationally, this could be overcome by giving two time series of F-estimates, one based on "exploitable biomass" (i.e. fully exploited F) and the other based on the total biomass of fish in the chosen length range (e.g. 80cm+ females). The difference between these would indicate changes in selectivity over time. The parallel presentation of the equilibrium pups-per-recruit is still important to indicate the biological implications of the year-specific selectivity patterns.

7.3.2 *Other methods examined*

Length Tuned Model

This model allowed the use of a greater range of survey data, including the winter NEFSC survey, as well as fishery catch and length frequency data. My general conclusion is that a length-based analytical model of this nature could provide a useful assessment tool to avoid over-dependence on very noisy survey data, but the present implementation of LTM does not provide credible results and should not be presented as part of the fishery management advice. The reasons are given below, following a brief description of what the model was fitting to.

The LTM was applied only to female dogfish, in line with the stochastic swept-area approach. The method was well explained at the SARC meeting. It gives estimates of recruitment trends dependent upon the penalty weight given to recruitment variation (Vrec), and tries to replicate the trends in quantity and length composition for 80cm+ females in catches and surveys. The spring 2006 survey estimate, which is anomalously high, was omitted from the LTM model but would have to be accommodated in future assessments.

Although the model uses a valid procedure for propagating length-at-age distributions through time, it does not appear to have been fully simulation tested using a true underlying age/length structured model and "assessment" data derived with a range of potential error structures. Hence it is not known if the model can potentially give unbiased results for a stock with the characteristics of spiny dogfish. The procedure adopted by the SAW was to explore a wide range of model settings. Unlike the application to black seabass, the sensitivity to the assumed growth curve was not explored.

A key aspect of the dynamics of the stock has been a contraction in the length range in the stock, reflecting the impact of negligible recruitment in recent years coincident with a decline in relative abundance of large females in recent years. The LTM is able to replicate the recent trend of poor recruitment, but cannot replicate the recent change in length composition of mature females. There could be a variety of reasons for this, including sensitivity to growth parameters or changes in growth over time, and incorrect selection curves. The use of an uninformative and very broad age/length composition in the starting year (1981) and in-filled catch length data for the 1980s, may be a contributing factor. The model appears to fit the observed total landings weight very closely, although there may in fact be greater uncertainty in total removals (landings plus dead discards) than allowed for in the model. The model appears to be in too early a stage of development to be presented to the fishery managers, and further development and testing is recommended.

Mass balance model and modified C-S model

This was carried out to address SARC 37 concerns possibility that trawl footprint of 0.01 gives biased B estimates, and is discussed under the section on stochastic swept area estimates.

Beverton – Holt method for F estimates

This was carried out to provide supporting evidence for trends in F and is not used for management decisions. The F estimates are generally consistent with the results of the stochastic swept-area method, although there will be a lagged response making it difficult to compare the figures for the more recent years.

7.4 Either update or re-estimate biological reference points (BRPs), as appropriate.

The SAW re-examined the Ricker stock-recruit model derived from NEFSC swept-area estimates. The recent series of poor recruitment alters the shape of the curve, displacing the peak to a higher biomass level. As the series of poor recruitments cause non-random residuals, the Ricker model was not considered valid for estimating SSB_{max}. Smoothed values are not affected by the recent recruitment. The concerns of the SAW about the instability of the Ricker model estimates of SSB_{max} are valid. However the existing $F_{threshold}$ of 100,000t is sensible as the probability of poor recruitment appears to be increased below this value.

The SAW recommended retention of the existing BRP. However the assessment summary report for 2006, as presented to SARC, gives various B_{target} values associated with different trawl footprints. The current biomass estimate is well below any of the B_{target} values given.

The overfishing threshold was updated using the same life history model on which the existing $F_{threhold}$ is based, but including the current size selectivity. This results in a revision of the threshold from 0.11 to 0.387. However, this represents the fishing mortality at the length at maximum selection, which now occurs towards the maximum length in the population, and the value only makes sense if viewed together with the selection curve. The SAW computed fishery selection curves for each year since 1985, using the mean NEFSC survey length frequencies as proxies for the true population length frequencies. These show quite dramatic changes in fishery selection curves over time to an extent that there are clearly a wide range of possible BRPs dependent upon the nature of the fishery. Although SARC participated in some extensive discussions with the assessment team regarding how to present BRPs under these circumstances, this is an issue that needs resolving with the fishery managers.

Information presented at SARC-43 indicated that smaller mature females produced smaller pups, and there was speculation that the survival of small pups may be poorer than for the larger pups. The inference was that the reduced mean length of mature females in recent years could be a contributing factor to the very poor recruitment observed. This is an aspect of the biology worth pursuing further, particularly with regard to the effect of different selectivity patterns on the longevity and size composition of females after they start reproducing.

7.5 Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

The current swept-area biomass estimate for mature female spiny dogfish is 106,000t, marginally above the $B_{threshold}$ of 100,000t but below the B_{target} of 200,000t. The figure for current biomass is heavily influenced by the very large estimate for 2006, which is influenced by a few very large tows. The large increase in one year from a biomass well below the threshold to a biomass slightly above the threshold seems implausible and is probably an unreliable result.

The large average biomass estimate for 2004-2006 also implies low fishing mortality of F=0.13, which will be an under-estimate if current biomass is over-estimated. Although the F estimate is close to the existing $F_{threshold}$ of 0.11, the latter is based on a selectivity pattern that may not reflect the current fishery, and the two values are not comparable. The current F should be comparable with the revised $F_{threshold}$ figure of 0.387, provided the selectivity curve applied in the stochastic swept area model is equivalent to the true selectivity in the fishery. On this basis, the current F is estimated to be below $F_{threshold}$ but this is heavily influenced by the large 2006 survey index of abundance.

7.6 Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

The Working Group determined that uncertainty in the recreational catch had little impact on the assessment results. Most of the recreational catch is discarded, and the discard mortality is thought to be relatively low.

7.7 Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

The Working Group recommended the approach used by SAW37, which is the stochastic length-based projection model. This model is consistent with the assessment model and is therefore appropriate to use.

7.8 If possible,

c. provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and

d. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

This ToR was completed. Projections were made over a 20-year period. The results for the first decade will be influenced almost entirely by the current population size and structure, as there has been an extended period of negligible recruitment. The projections may be over-optimistic as the starting biomass (106,000t) is much higher than for earlier years because of the anomalously high survey estimate for 2006, and the status quo F may be correspondingly too low. This may be responsible for the short-term increase in biomass before the stock declines in response to the recent period of weak recruitment. An alternative approach would be to commence the projections from an earlier recent year with more reliable estimates of biomass and F. This would probably result in a decline in biomass in the short term.

7.9 Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

The assessment report lists the recommendations from the previous SARC and the extent to which these have been addressed. Nine of the eleven recommendations were completed or in progress. The two recommendations on which no progress was made were to conduct experimental work on NEFSC trawl survey gear performance, focusing on video work to study herding, and to investigate the distribution of spiny dogfish beyond the depth range of the current NEFSC surveys. The first of these remains a valid recommendation. The second recommendation may be addressed with the new research vessel and gear in coming years. Data may also be available from the monkfish surveys, which were not presented to SARC-43.

7.10 Further research recommendations

I have the following research recommendations:

- Further exploration of length-based analytical models to overcome the dependence on noisy survey data for management;

- Continue with ageing studies to provide data for conditioning the length-based models;

- Investigate spiny dogfish distribution in deeper water beyond the historical NEFSC trawl surveys, using data from the monkfish surveys and any new surveys extending into deeper water.

7.11 Discussion topics outside the Terms of Reference

There were no important discussion topics not related to the existing Terms of Reference.

Annex II: Review Report by Mark Maunder

43rd NORTHEAST REGIONAL STOCK ASSESSMENT REVIEW COMMITTEE (SARC-43)

SARC-43, June 6 – June 9, 2006
Woods Hole, MA

Report on the 2006 assessments of black sea bass (*Centropritis striata*), spiny dogfish (*Squalus acanthias*), ocean quahog clams (*Arctica islandica*) and deep sea red crab (*Chaceon quinquedens*) in the Northeast United States

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Mark Maunder

Prepared for:
The Center for Independent Experts,
University of Miami

Prepared by:
Mark Maunder
Quantitative Resource Assessment LLC
8311 Bryn Glen Way
San Diego CA, 92129
mmaunder@iattc.org

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Contents

Page

1. Background

This report provides an independent review of the four east coast assessments of black sea bass (*Centropritis striata*), spiny dogfish (*Squalus acanthias*), ocean quahog clams (*Arctica islandica*) and deep sea red crab (*Chaceon quinquedens*) conducted for the Center for Independent Experts, University of Miami. The assessments were reviewed during the 43rd Northeast Regional Stock Assessment Review Committee meeting held at Woods Hole, MA, June 6 – June 9, 2006. The contents of this report are summarized in the Panel report, which is a consensus of all Panel members.

2. Description of review activities

The Panel convened at the Woods Hole Laboratory of the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts, from June 6-12, 2006. The Committee comprised a chair and two panelists.

Prior to the meeting, the assessments and background material were provided via a website. This material was reviewed in preparation for the meeting.

The assessments of the four stocks were presented during the public 43rd Northeast Regional Stock Assessment Review Committee meeting held at Woods Hole, MA, June 6 – June 9, 2006. The presenters returned, if required, to follow up on unanswered questions and clarification of how the SAW Terms of Reference were addressed.

After the completion of the Stock Assessment Review Committee meeting, the Panelists convened in private session to write their individual reports and the Panel consensus report. The reports state how each Term of Reference of the relevant SAW was addressed focusing on: i) whether the work that was presented is acceptable based on scientific criteria; and ii) whether the work provides a scientifically credible basis for developing fishery management advice.

Several simple analyses were carried out to help understand the assessments carried out by the SAWs. Where appropriate these have been described in this report.

3. Assessment of deep sea red crab

Fishing mortality and biomass were estimated appropriately and provide scientifically credible basis for developing fishery management advice provided the uncertainty regarding assumptions is taken into consideration. However, representation of uncertainty was problematic. No appropriate reference points are available. The assessment for deep-sea red crab is based on camera surveys, one in 1974 and four during 2003-2005. The status of the stock was determined based on a) comparison of biomass estimates, and sex and length-structure among these surveys and b) estimation of fishing mortality from the ratio of current catch divided by current exploitable biomass estimated from the average of the 2003-2005 surveys. It was not possible to develop appropriate reference points for this stock due to lack of biological information and the existing MSY reference point does not provide a scientifically credible basis for developing fishery management advice. However, the assessment indicates that the exploitation rates are low and the current biomass is a high proportion of the virgin biomass. The main concern for this stock is the skewed sex ratio and the lack of large males that may be necessary for reproductive success due to the mating behavior (a male needs to be 50% larger than the female). In addition, there is a large amount of discards for which the survival rate is unknown.

3.1 Characterize the commercial and recreational catch including landings and discards.

The commercial catch, discards and their uncertainty were characterized appropriately. There is no recreational catch for this stock.

The Historical catch data is uncertain prior to about 1992 because there was no requirement for reporting. Catch before 1982 was not provided. Recent estimates suggest that about one third of the catch is discarded, but historical estimates are not available. The discards are mainly females and small males. Discard rates are likely to have changed over time as the sex and size structure changed and the desired size of crabs reduced from 114+ mm in 1974 to the current level of about 92+ mm. The survival rate of discards is unknown. Therefore, historical mortality due to fishing is highly uncertain. There is no recreational catch for this species. The historical estimates of catch were not used in the calculation of abundance or fishing mortality.

Length-frequency of the catch is only available for 2001-2005 and the coverage is low in areas A and B, with no samples for some years. The survey length frequency data suggest that the size structure of the population differs among areas and changes seasonally. There are also depth differences in size and sex-structure. The selectivity of the fishery and discarding has changed over time due to the acceptable size of crabs reducing from 114+ mm in 1974 to the current level of about 92+ mm. The surveys suggest that the population size and sex structure has changed substantially over time. Therefore, historic length distributions of the catch are uncertain.

3.2 Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

Fishing mortality and biomass were estimated appropriately and provide a scientifically credible basis for developing fishery management advice provided the uncertainty regarding assumptions is taken into consideration. However, representation of uncertainty was problematic. Biomass was estimated from camera based surveys in 1974 and 2003-2005 and average fishing mortality was estimated for 2003-2005. Biomass and fishing mortality rates were not estimated for other years. The assessment appropriately only used the current catch data, because historical catch is highly uncertain. No estimate of spawning biomass was provided.

Biomass was estimated from camera based surveys in 1974 and 2003-2005. Biomass was estimated for several components of the population relating to total and exploitable biomass based on the survey length-frequency data. However, a measure of spawning biomass was not presented. Total biomass increased, but the exploitable biomass (mainly large males) decreased from 1974 to 2003-2005. The increase in total biomass is due to the higher abundance of small crabs in the 2003-2005 surveys. This may be due to higher recruitment in recent years or because the efficiency for detecting small crabs may differ between 1974 and 2003-2005 surveys. Estimates of small crabs should not be included in depletion quantities used for management advice. There were several other problems identified with the survey. The 2003-2005 surveys did not extend as far north as the 1974 survey, but the estimates of abundance were extrapolated to cover this area. The smaller sled used in 2003-2005 may underestimate biomass due to crab avoidance and the smaller camera area coverage. Habitat (except depth) was not taken into consideration in the expansion of the survey. The absolute abundance estimates may be over estimated due to unsuitable habitat included in the expansion factors.

The assessment report did not provide estimates for each of the 2003-2005 surveys, only the averages. The review panel requested that the results, including length-frequency data, be presented for each survey. This provided a better understanding of the surveys and how the 1974 estimate compared to the variation among the 2003-2005 survey estimates. The June 2003 survey had lower sample size than the other surveys and its estimates were the most different. All but one of the surveys were carried out in June. The August 2003 survey had substantially different length-frequency distributions by area than the June surveys.

The species is thought to have a moderate level of longevity and the population size and size-structure will change over time. Therefore, it may not be appropriate to average multiple years to calculate biomass and fishing mortality. However, the results are similar for all surveys and using different years to calculate the abundance or fishing mortality would not influence overall conclusions.

No estimate of the spawning biomass was presented. It is difficult to define the spawning biomass for this stock because females require a male about 50% larger to mate. Therefore, loss of large males due to the fishery selectivity may impact reproduction.

The standard deviations used for the biomass estimates were based on the mean of four estimates. These are misleading because they do not take the uncertainty in the individual estimates into consideration. The uncertainty in the individual estimates should take into consideration the sampling error and error in assumptions (e.g. see the quahog surveys). It is not known how considering the variation in the individual estimates would influence the variance estimates. The variance may reduce because the June 2003 survey was the most different, but had the lowest sample size. The variance may increase due to including error in the assumptions.

There are substantial differences in the CPUE trends and survey length-frequencies among the four areas. This indicates that the exploitation history or biological parameters may differ among the areas. The status of the stock may differ among areas.

Current fishing mortality was estimated as current catch divided by current biomass. The current biomass was estimated as the average biomass from the 4 surveys in 2003-2005. The fishing mortality estimates do not include discard mortality. Therefore, they may be somewhat higher. However, this calculation is complicated, because the discards are of females and small males so the definition of the exploitable biomass would be different than used in the current fishing mortality calculations. The fishing mortality on fully selected crabs may not change.

3. 3 Either update or re-estimate biological reference points (BRPs), as appropriate.

Biological reference points were not updated. There was no new information that could be used to update the existing reference point. The data are inadequate and the reference point does not provide a scientifically credible basis for developing fishery management advice.

The current reference point $0.5MB_0$ ($M = 0.2$ and B_0 = 1974 estimate of 114+ mm males) is inappropriate. There is a lack of information about the biological processes required to determine MSY. The assumption that Bmsy = $0.5B_0$ is generally not consistent with a population with $M = 0.2$. A more appropriate value may be around 0.3. This suggests that MSY is over estimated. However, the definition of B_0 is not consistent with the current selectivity and the B_0 defined using the current selectivity would be higher, which would increase the MSY. MSY is a function of biological processes (e.g. growth, natural mortality, stock-recruitment relationship) and the selectivity of the gear. The biological reference point should be reevaluated taking these into consideration. However, there is large uncertainty in the biological processes. Therefore, the current MSY reference point does not provide a scientifically credible basis for developing fishery management advice.

The use of Bmsy = 0.5B0 as a reference point, as noted in the executive summary, may be less problematic and more conservative than the MSY reference point, but it still retains the problems identified above. In particular, the definition of biomass used to calculate Bmsy is problematic for this stock. Therefore, the Bmsy reference point does not provide a scientifically credible basis for developing fishery management advice.

3.4 Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

See 3.

3.5 Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

Data were inadequate to provide scientifically credible projections for developing fishery management advice.

3.6 If possible,

e. **provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and**

f. **compare projected stock status to existing rebuilding or recovery schedules, as appropriate.**

Projections were not possible.

3.7 Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

There were no research recommendations from the previous assessment.

3.8 Additional comments unrelated to the TOR

There were no additional comments unrelated to the TOR.

3.9 Recommendations for future assessments

An appropriate measure for reproductive potential should be developed.

More biological data should be collected (e.g. growth and natural mortality).

Appropriate biological reference points or other indicators useful for management advice that are consistent with the data available for this species should be developed.

4. Assessment of ocean quahog (text omitted)

5. Assessment of black sea bass

Reference points and estimates of biomass trends and fishing mortality do not provide a scientifically credible basis for developing fishery management advice. The fishing mortality reference point proxy (Fmax) may not be appropriate for this population and is calculated based on quantities that are uncertain. The biomass reference point is based on a survey index that is probably influenced by a few large catches. Fishing mortality estimates are based on tagging that has inconsistent recoveries between the first year and latter years. The Length Tuned Model shows promise, but needs to be improved.

5.1 Characterize the commercial and recreational catch including landings and discards.

The commercial catch, discards and their uncertainty were characterized appropriately. However, these are not used in the assessment to provide management advice.

There are substantial levels of commercial, recreational, and discards for this stock. There is uncertainty in the commercial discards, which are determined based on logbook data, and in the survival of discards from the commercial fleet. Discards have probably increased due to changes in MLS and the introduction of quotas and trip limits. Recreational discard mortality is around 15%.

5.2 Describe temporal trends in abundance and size-structure based on data from NEFSC surveys. When possible, characterize the uncertainty of point estimates. Describe data from other surveys, as appropriate.

The temporal trends in abundance and size-structure based on data from NEFSC surveys and their uncertainty were characterized. However, there was inconsistency about the best methods to represent the index values and their uncertainty. Therefore, it is questionable if the surveys can be used for management advice.

The survey data were presented as a mixture of log-retransformed (geometric means) and arithmetic means. These approaches can give substantially different results when there are a few large tows that influence the results. In particular, the spring survey, which is used to develop the biomass biological reference point, has huge confidence intervals for all years and large index values for the three years (1977-1979) averaged for the biomass reference point. The log-retransformed index has much smaller confidence intervals and average values for the three years used for the biomass reference point. More attention is needed in developing indices of abundance from these surveys.

The surveys that represent recruitment to the stock suggest recent large cohorts that are consistent with the increased abundance seen in the NEFSC Spring and Winter surveys. However, the declines seen in recent years in the NEFSC Spring and Winter surveys may not be consistent with the stock dynamics unless there is large mortality occurring due to fishing or natural causes. This is supported by the results of the Length Tuned Model, which is unable to fit the decline in the survey index.

5.3 Describe migration patterns based on data from the recent tagging study.

The migration patterns based on data from the recent tagging study were described adequately. Exploitation rates may bias movement estimates, but plots of CPUE and catch show that the “sampling” of tags was reasonably consistent with the density of sea bass.

Tagging analyses that include movement were not carried out.

5.4 Estimate annual rates of fishing mortality and total mortality, based on the recent tagging study. Characterize the uncertainty of those estimates.

The analyses and data were not adequate to provide a scientifically credible basis for developing fishery management advice. Results of the Brownie model suggest that the fishing mortality estimates from the R/M method may be unreliable.

Two analyses were carried out to estimate fishing mortality from the tagging data. The first, a R/M model, only used recaptures for the year following the releases (except for the analysis that was used to estimate M). The second, a Brownie model, used all recaptures and was used to investigate more complex population dynamics. The R/M model was chosen over the Brownie model because the Brownie model produced unrealistic results in some cases and was sensitive to some parameter values. The results from the seasonal Brownie model were more similar to those from the R/M model.

The Brownie model indicated that there was an inconsistency between the first year of recaptures and following years of recaptures. Estimates of exploitation rate can be calculated for the second and third year of recaptures by adjusting the releases for the tag recaptures in previous years and the natural mortality ($M = 0.2$). The estimates of exploitation rates for the first year of recaptures average 0.26 over the four release groups, but in the estimates for the subsequent years of recaptures averages 0.06 (see Appendix). This indicates that there is a process operating in the first year of recapture that may bias the results (e.g. non mixing of fish, additional tag loss or mortality) or that some other assumption in the model is wrong (e.g. natural mortality is different than assumed, seasonal structure or movement between areas is important). Therefore the estimates from the simple R/M may be unreliable. A quick analysis (see Appendix) indicates support for non-mixing over a different value for natural mortality or tag loss/mortality. However, more work is needed.

It appears that the reporting rate was calculated and used separately for each year or release group in the analysis. This essentially removes all information from regular reward tags and results are based only on the high reward tags. The high rewards have very low sample sizes, therefore, if this is the case, the results will be much less precise than assumed from the low reward release number. Information from the regular reward tags would be used if the reporting rate was assumed constant over time.

5.5 Evaluate current stock status with respect to the existing BRPs.

The data are inadequate and the reference points do not provide a scientifically credible basis for developing fishery management advice.

Fmax is used as a proxy for Fmsy, which is the fishing mortality threshold reference point. NEFSC spring survey biomass per tow for fish greater than or equal to 22 cm is used as a proxy for the minimum biomass threshold and is calculated as the mean index from the period 1977 to 1979.

Fmax is a poor proxy for Fmsy when there is a stock recruitment relationship and will over estimate Fmsy. There is also uncertainty in the parameters used to calculate Fmax from the YPR analysis (e.g. growth and natural mortality). The estimates of fishing mortality from the R/M analysis are unreliable as mentioned above.

There are several uncertainties in the NEFSC spring survey index used for the biomass reference point as mentioned above. This survey has huge confidence intervals for all years and there is probably no statistical difference between the reference point and the current biomass. In contrast, the log-retransformed index has much smaller confidence intervals, but the average values for the three years used for the biomass reference point are much lower and the current biomass is probably significantly above the biomass reference point. If the concept of the highest biomass observed in the survey is taken as the reference point (1974-1976), the current biomass is probably significantly below the reference point using the log-retransformed index. However, the concept of using the highest observed biomass as a minimum biomass threshold is counter intuitive. The standard approach is to use the lowest observed biomass as a minimum biomass threshold because there is evidence that the population is sustainable at all biomass levels above that minimum. The highest observed biomass might be more appropriate as a short term rebuilding target.

5.6 Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

The recreational catch was not used in the assessment. Sensitivity to the recreational catch was evaluated in the LTM.

5.7 Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in the previous SARC-reviewed assessment.

More comprehensive evaluation of regional survey data is required to give more integrated indices of recruitment.

The WG did not make progress on this research recommendation.

Adequate sampling of both commercial and recreational catches should be implemented with a view to improving knowledge of discarding and what affects it, so reducing one of the uncertainties inherent in the catch series.

Commercial and recreational length sampling intensity has improved since the last assessment. However, discard sampling is expected to decline. This recommendation is important and effort should be made to carry it out.

Both accuracy and completeness of catch data, particularly recreational catch, should be investigated to explain unusual inter-annual variability.

Only limited progress was made on this recommendation. Similar analyses should be carried out when the LTM is improved.

Attempts should be made to extract as much information as possible from all time-series considered appropriate using, for example, a GLM or GAM approach to combine the various surveys and gear types into a standardized index.

The Working Group made no progress on this recommendation.

Confidence limits for survey-based estimates of recreational catch should be derived and presented.

Estimates of proportional standard error are included with the recreational catch estimates.

Ageing of samples of black sea bass should be initiated as soon as possible, and survey indices need to be disaggregated by age to identify the impact of year-class variation in the biomass index and to investigate the magnitude of year effects.

No progress was made in aging the backlog of age samples. This recommendation should be a priority.

A standard assessment based on a population model should be developed for the stock. A catch-at-age model would seem to be the most appropriate.

A length tuned model (LTM) was developed for the stock. Once the LTM is improved, it will be valuable for evaluating the different data sets and assessing the stock. Inclusion of the tagging data in the model should be considered.

Clarification is needed whether the bias introduced on back-transforming from *length-weight relationship has been corrected for in the assessment. If not, it should be.*

No progress made on this recommendation.

If financially feasible, tagging studies should continue (at least sporadically), to permit return rates over longer periods and the stability of estimates of exploitation rate to be established. Further, long-term data on rates of tag loss need to be collected through the tagging program.

The tag release program for black sea bass has been completed. Recoveries continue to be collected and included in analysis. If the tagging program is going to be used as the main assessment tool for this species, the recommendation needs to be followed.

A more sophisticated analytical model such as the Brownie with a migration extension should be applied to the tagging data.

The Working Group completed analysis of tagging data with a Brownie model however a migration extension was not included due to limited data. The model needs to be improved and used as a tool to identify the inconsistencies between the first year recaptures and later year recaptures.

Improved education and awareness programs should be initiated in an attempt to improve tag return rates.

The tag release program for black sea bass has been completed and no funds are available for continued outreach programs.

The relationship between offshore distribution patterns and environmental variables such as temperature and frontal systems should be investigated, to ensure that catchability effects are not driving trends in the spring surveys.

No further progress has been completed on this recommendation.

5.8 Additional comments unrelated to the TOR

A length tuned model was developed for this stock. The model shows potential, but needs some improvements. The fisheries need to be modeled separately to allow for the appropriate selectivity to be applied. Similarly, discards need to be explicitly modeled. The likelihood functions should be applied using appropriate standard deviations or effective sample sizes and these modified rather than using lambdas. All the survey length-frequency data should be included in the model. Including the tagging data in the model should be considered. The use of Stock Synthesis II should be considered.

5.9 Recommendations for future assessments

Aging data should be collected and growth curves developed (including variation of length-at-age for use in catch-at-length models).

Tag recoveries should be continued.

More tag releases should be carried out.

The tagging analyses should be improved and include spatial and seasonal components.

More appropriate reference points should be developed

5.10 Appendix 1

A model similar to the Brownie model is used to investigate the tagging data.

Tag dynamics

$N^i_{j,y} = R^i_j(1-\omega-\upsilon)$ if y is the year of release

$$N^i_{j,y+1} = N^i_{j,y}\exp(-Z_{j,y})$$

$Z_{j,y} = M + \phi F_y$ if y is the year of release

$$Z_{j,y} = M + F_y$$

Where $N^i_{j,y}$ is the number of tagged fish alive with tag type i from release group j at the start of year y, $\omega = 0.08$ is the tag loss, $\upsilon = 0.02$ is the tag mortality, $Z_{j,y}$ is the total mortality for release group j in year y, M is the natural mortality, F_y is the fishing mortality in year y, and ϕ scales the fishing mortality in the first year of release to account for non-mixing of tagged fish.

Predicted recaptures

Regular tags

$\hat{m}^r_{j,y} = \tau\frac{\phi F_y}{Z_{j,y}}N^r_{j,y}\left(1-\exp(-Z_{j,y})\right)$ if y is the year of release

$$\hat{m}^r_{j,y} = \tau\frac{F_y}{Z_{j,y}}N^r_{j,y}\left(1-\exp(-Z_{j,y})\right)$$

Where $\hat{m}^r_{j,y}$ is the predicted recoveries of regular tags from release group j in year y and τ is the tag reporting rate

High value tags

$\hat{m}^h_{j,y} = \frac{\phi F_y}{Z_{j,y}}N^h_{j,y}\left(1-\exp(-Z_{j,y})\right)$ if y is the year of release

$$\hat{m}^h_{j,y} = \frac{F_y}{Z_{j,y}}N^h_{j,y}\left(1-\exp(-Z_{j,y})\right)$$

Where $\hat{m}^h_{j,y}$ is the predicted recoveries of high value tags from release group *j* in year *y*.

Likelihood

$$-\ln\left[L(\boldsymbol{\theta} \mid \mathbf{m})\right] = \sum_{i,j,y}\left(\ln[\sigma] + \frac{\left(\ln\left[m_{i,j,y}\right] - \ln\left[\hat{m}_{i,j,y}\right]\right)^2}{2\sigma^2}\right)$$

The results support incomplete mixing as the most likely explanation. However, even for this model the results appear unrealistic. The model would be improved by including seasonal dynamics, which would also allow for the incorporation of the Spring 2003 releases. There may be a more appropriate likelihood. The model could be extended to include movement between the areas.

	Base	Mixing	M	Tag loss/mortality
-ln(Likelihood)	3.15	-12.49	-4.61	-5.33
Max gradient	6.69E-05	2.15E-05	1.61E-05	7.12E-05
F2002	0.71	0.03	0.27	1.04
F2003	0.25	0.05	0.37	1.65
F2004	0.11	0.04	0.36	3.41
M	0.20	0.20	1.15	0.20
Tag loss	0.08	0.08	0.08	0.77
Tag Mortality	0.02	0.02	0.02	0.02
F release scale	1.00	6.39	1.00	1.00
Reporting rate	0.45	0.67	0.67	0.67
Sd	0.79	0.21	0.41	0.39

AD Model Builder Code

TPL file

```
DATA_SECTION
  init_int StartYear
  init_int EndYear
  init_int Nreleases
  init_matrix Releases_regular(1,Nreleases,1,2)
  init_matrix Recoveries_regular(1,Nreleases,StartYear,EndYear)
  init_matrix Releases_high(1,Nreleases,1,2)
  init_matrix Recoveries_high(1,Nreleases,StartYear,EndYear)

PARAMETER_SECTION
  init_bounded_vector F(StartYear,EndYear,0.01,10,1)
  init_number M(-2)
  init_number TagLoss(-2)
  init_number TagMortality(-1)
  init_number Fscale(-2)
  init_bounded_number ReportingRate(0.01,1.0,2)
  init_bounded_number sd(0.01,10,3)

  matrix N_regular(1,Nreleases,StartYear,EndYear)
  matrix N_high(1,Nreleases,StartYear,EndYear)
  matrix Pred_Recoveries_regular(1,Nreleases,StartYear,EndYear)
  matrix Pred_Recoveries_high(1,Nreleases,StartYear,EndYear)
```

```
  matrix Z(1,Nreleases,StartYear,EndYear)

  matrix Like_regular(1,Nreleases,StartYear,EndYear)
  matrix Like_high(1,Nreleases,StartYear,EndYear)

  objective_function_value f

PROCEDURE_SECTION
  f=0;
  for(int j=1;j<=Nreleases;j++)
  {
		for(int y=Releases_regular(j,1); y<=EndYear;y++)
		{
			//First Year
			if(y==Releases_regular(j,1))
			{
				N_regular(j,y)=Releases_regular(j,2)*(1-TagLoss-TagMortality);
				N_high(j,y)=Releases_high(j,2)*(1-TagLoss-TagMortality);
				Z(j,y)=M+Fscale*F(y);
				Pred_Recoveries_regular(j,y)=ReportingRate*(Fscale*F(y)/Z(j,y))*N_regular(j,y)*(1-
mfexp(-Z(j,y)));
				Pred_Recoveries_high(j,y)=(Fscale*F(y)/Z(j,y))*N_high(j,y)*(1-mfexp(-Z(j,y)));
			}
			//Other Years
			else
			{
				N_regular(j,y)=N_regular(j,y-1)*mfexp(-Z(j,y-1));
				N_high(j,y)=N_high(j,y-1)*mfexp(-Z(j,y-1));
				Z(j,y)=M+F(y);
				Pred_Recoveries_regular(j,y)=ReportingRate*(F(y)/Z(j,y))*N_regular(j,y)*(1-mfexp(-
Z(j,y)));
				Pred_Recoveries_high(j,y)=(F(y)/Z(j,y))*N_high(j,y)*(1-mfexp(-Z(j,y)));

			}
			Like_regular(j,y)=log(sd)+square(log(Recoveries_regular(j,y))-
log(Pred_Recoveries_regular(j,y)))/(2*sd*sd);
			Like_high(j,y)=log(sd)+square(log(Recoveries_high(j,y))-
log(Pred_Recoveries_high(j,y)))/(2*sd*sd);
			f+=Like_regular(j,y)+Like_high(j,y);
		}
  }



REPORT_SECTION
  report<<"Pred_Recoveries_regular"<<endl;
  report<<Pred_Recoveries_regular<<endl;
  report<<"Pred_Recoveries_high"<<endl;
  report<<Pred_Recoveries_high<<endl;
  report<<"N_regular"<<endl;
  report<<N_regular<<endl;
  report<<"N_high"<<endl;
  report<<N_high<<endl;
```

DAT file

```
#init_int StartYear
2002
#init_int EndYear
2004
#init_int Nreleases
3
#init_matrix Releases_regular(1,Nreleases,1,2)
#year number
2002 3143
2003 2449
2004 2854
#init_matrix Recoveries_regular(1,Nreleases,StartYear,EndYear)
289	63	23
0	355	46
0	0	346
#init_matrix Releases_high(1,Nreleases,1,2)
2002 279
```

```
2003 232
2004 178
#init_matrix Recoveries_high(1,Nreleases,StartYear,EndYear)
39	9	5
0	49	3
0	0	39
```

PIN file

```
#init_vector F(StartYear,EndYear,1)
0.2 0.2 0.2
#init_number M(-1)
0.2
#init_number TagLoss(-1)
0.08
#init_number TagMortality(-1)
0.02
#init_number Fscale(-1)
1.0
#init_number ReportingRate(1)
0.60
#init_number sd(1)
0.3
```

5.11 Appendix 2

Estimating fishing mortality from multiple years of recoveries from a single release

The same methods as presented in Appendix 1 can be used with only as single release group. This basically adjusts the releases to the appropriate numbers in the second and third years so that the fishing mortality for those years can be estimated.

	Recapture		
Release	2002	2003	2004
2002	0.21	0.07	0.04
2002 Spring	0.28	0.11	0.04
2003		0.24	0.03
2004			0.31

6. Assessment of spiny dogfish

It is unclear if the estimates of abundance and fishing mortality, and reference points, provide credible scientific advice. Several methods have been applied to determine estimates of absolute abundance and fishing mortality. However, these estimates have not been presented in a consistent way to make easy comparisons. There is some consistency among the estimates of fishing mortality and biomass from the different methods. However, there is still large uncertainty in these estimates. The LTM requires several improvements before it can be considered appropriate for providing scientifically credible management advice. The use of the survey to estimate trends in biomass and fishing mortality may be more scientifically credible than its use for absolute estimates. However, the high biomass estimate in 2006 and the corresponding low fishing mortality should be viewed cautiously. Future reports need to formatted to allow easier interpretation and comparison of results. A consistent method is needed for all components of the report including assessment, reference points, and projections. The main concerns for this stock are the reduction in female abundance, imbalance in the sex ratio, and the low estimates of recent recruitment. Discards are a very large component of the fishing induced mortality and need to be monitored.

6.1 Characterize the commercial and recreational catch including landings and discards.

The commercial and recreational catch, discards, and their uncertainty were characterized appropriately. However, the discards comprise a very large component of the fishery and discard rates for early years and the survival rate are uncertain. The length-frequency of the large foreign catch in early years is unknown and there is little information about the recreational length-frequency.

Discards were estimated with a new approach based on using total catch of all species as a proxy for effort because total effort is uncertain (size of vessels etc). Total catch of all species was used because in some years the amount of retained dogfish is very small. The method is very imprecise with large cvs. Survival estimates of discarded dogfish are also uncertain.

The amounts of discards have changed over time due to management regulations, economic factors, effort, and availability of the stock, among other factors. This has modified the length-frequency of the retained catches and influences estimates of selectivity. Recreational length-frequency and thus selectivity is assumed equal to otter trawl.

The temporal and spatial patterns of dogfish landings are closely tied to the north-south migration patterns of the stock. There has also been a redistribution of abundance inshore over time.

Determining discard mortality and sex composition are important for this stock and have appropriately been given much attention.

6.2 Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

Several methods have been applied to determine estimates of absolute abundance and fishing mortality. However, these estimates have not been presented in a consistent way to make easy comparisons. There is some consistency among the estimates of fishing mortality and biomass form the different methods. However, there is still large uncertainty in these estimates. The LTM requires several improvements before it can be considered appropriate for providing scientifically credible management advice. The use of the survey to estimate trends in biomass and fishing mortality may be more scientifically credible than its use for absolute estimates.

Biomass was estimated using the swept area survey method and fishing mortality was estimated as catch divided by biomass. Three year moving averages were used for biomass because the survey estimates were highly variable. A length tuned stock assessment model (LTM) was developed as an alternative method to estimate biomass and fishing mortality. The LTM provides an alternative method to smooth and scale the survey estimates of biomass. A consistent decline in the average size of females in all surveys supports an impact of the fishery on the females.

Developing absolute estimates of abundance from surveys requires strong assumptions about the “footprint” of the survey gear. There are wide fluctuations in the spring survey estimates that are inconsistent with the dynamics of a slow growing stock with low productivity. This may indicate changes in the availability of the stock, particularly with strong seasonal migrations occurring northward in the spring and summer and southward in the fall and winter. The Leslie-Davis and Collie Sissenwine models support the estimates of the survey footprint. However, these models have several simplifying assumptions and it was unclear if the analyses were reliable. The analyses are sensitive to the assumptions about population growth rates as the size structure changes, and to the years of survey data that are used in the models (see Appendix). There are several factors that indicate uncertainties in the footprint. Dogfish school by size and there are a large number of zero tows (40-60%) with a small proportion of the tows (1-2%) making up a large proportion of the catch (40-60%) in many years. The amount of herding by the trawl gear is unknown and it is uncertain if the trawl door spread or the wing spread describe the footprint of the survey gear. The winter survey, which has different gear than the spring survey, has a much higher CPUE than the spring survey indicating that the spring survey may not capture all the dogfish in the assumed footprint. The trawl door or wing spread may change with depth causing a bias or variance in the area swept estimates in biomass. Dogfish have moved more inshore into shallower water over time, which may cause a bias in the relative trends from the survey. Smaller dogfish are thought to be more pelagic increasing the possibility of escapement over the trawl gear and this may cause additional bias in the estimates.

Estimates of biomass and fishing mortality may be best viewed in relative terms rather than absolute. However, this makes definition and comparison to reference points problematic. The high biomass estimate in 2006 and the corresponding low fishing mortality should be viewed cautiously.

Recent recruitments are the lowest that have been estimated, and this is a concern for this stock. The average number of pups and average size of pups has been decreasing over time with the decreasing average size of females.

The LTM shows promise as an alternative method to estimate biomass and fishing mortality. However, there are several improvements that are needed before it would be suitable to provide credible scientific advice. The application used length-frequency data from 1982-1991 that was constructed using values from the 90s and this is not appropriate. The model should be modified to allow each fishery to be included and its selectivity estimated within the model. This should include explicit modeling of discards and the length-specific retention. The selectivity patterns for some gears may be dome-shaped. The model should be fit to length data available for each fishery. This would eliminate the need for constructing early length-frequency data. The LTM ignored abundance and length-frequency data for mid-sized dogfish and this should be included in the model. The model needs to include appropriate weighting factors for each data set. I suggest using likelihood functions and specifying or estimating the standard deviations of the likelihood functions rather than modifying lambdas. The length-frequency data sample sizes need particular attention because dogfish school by size and sex. The survey data points should include their individual cvs to scale the standard deviations used in the likelihood functions. The LTM results were sensitive to the von Bertalanffy asymptotic length and may also be sensitive to the variation of length-at-age. More data on the growth curve and variation of length-at-age is needed. The model should be sexed structured and include data on both males and females.

There was high foreign catch in early years similar to the current levels of catch. However, this occurred when the survey index was increasing or stable. The length-frequency of these fleets is unknown, however they are thought to have captured a wide range of sizes compared to recent commercial fleets.

6.3 Either update or re-estimate biological reference points (BRPs), as appropriate.

It is unclear if the reference points are appropriate to provide scientifically credible advice.

The threshold fishing mortality reference point was updated using the same life history model as in the previous assessment, but included the current size selectivity of the fishery. However, the selectivity curve only includes full selectivity for the largest dogfish. Therefore, the revised estimate (0.387) is much higher than in the previous assessment. This reference point is very sensitive to the selectivity, which changes substantially over time. However, if the same selectivity is used to estimate F, then the comparison is consistent.

The Working Group considered the biomass biological reference points based on the Ricker Stock-Recruitment model to be unreliable because of the recent low recruitments that were not consistent with this model. Therefore, they did not update the reference point. However, the current threshold reference point (estimated from the previous assessment) appears reasonable because there is a high probability of low recruitment below this biomass level based on the survey data. One benefit of this reference point is that spawning biomass and recruitment can be used as relative values and are therefore less impacted by error in the estimates of the survey footprint as long as both the reference point and the comparison biomass are calculated from the same survey and footprint.

Other reference points were left as in the previous assessment.

6.4 Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

As noted above, it is unclear if evaluating the stock status with respect to the reference points provides scientifically credible advice for management. The high biomass estimate in 2006 and the corresponding low fishing mortality should be viewed cautiously.

The current biomass estimates are uncertain and the biomass reference point was considered problematic. However, the nature of the reference point reduces the influence of the uncertainty in the survey foot print (see above)

The current fishing mortality estimates are uncertain and the fishing mortality threshold reference point is sensitive to the selectivity pattern. The same selectivity pattern should be used for the biological reference point and the current estimate of fishing mortality. The selectivity pattern is highly variable over time and is related to the relative effort by each fishing method and the rate of discarding.

6.5 Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

It was difficult to determine from the report the exact proportion the recreational induced mortality contributed as a fraction of the total fishery induced mortality. However, it appears to be low and the results would not be overly sensitive to the uncertainty in the recreational catch and discard data.

6.6 Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

The projection model (or the other models) should be modified to be consistent with the other models used for assessment and reference points. For example, the biomass reference points are based on a Ricker stock-recruitment model, but the projection model assumes recruitment proportional to females. If the LTM is improved and used in future assessments, it should also be used for projections. Variation in recruitment should also be included in the model.

6.7 If possible,

e. **provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and**

f. **compare projected stock status to existing rebuilding or recovery schedules, as appropriate.**

The projections do not provide scientifically credible advice for management.

The results were not included in the report but presented at the review. The projections are based on estimates of current biomass that depend on the swept area survey estimates and therefore have the associated uncertainties. The projected fishing mortality rates are also uncertain. The projections will be influenced by the selectivity chosen and selectivity is highly variable from year to year. They were also influenced by the high biomass estimate in 2006 and the corresponding low fishing mortality, which should be viewed cautiously.

6.8 Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

Attempt to allocate landings to statistical area (i.e. attempt proration) using Vessel Trip Report data for 1994 and later years.

This was completed.

Evaluate the utility of length frequency for spiny dogfish sampled in the NEFSC Observer Program in the most recent years (2001 and later).

A length tuned model and a Beverton-Holt estimator for F were used. The LTM needs to be improved and is a better method to evaluate the information from the length data than the Beverton-Holt estimator.

Ensure the inclusion of recent (2000 and later) MADMF Observer sample data for spiny dogfish in the NEFSC database, for more efficient use in future assessments.

This was completed.

Conduct tagging and genetic studies of spiny dogfish in U.S. and Canadian waters to clarify current assumptions about stock structure.

The Working Group reviewed an ongoing streamer tag project conducted by East Carolina University.

Conduct discard mortality studies for spiny dogfish, with consideration of the differences in mortality rates among seasons, areas, and gear types.

The Working Group reviewed a discard mortality study in North Carolina near-shore trawl and gillnet fisheries conducted by East Carolina University, and took these results into consideration in updating assumed discard mortality rates for the coast-wide trawl, gillnet, and hook fisheries.

Conduct experimental work on NEFSC trawl survey gear performance, with focus on video work to study the fish herding properties of the gear for species like dogfish and other demersal roundfish.

The Working Group made no progress on this RR.

Investigate the distribution of spiny dogfish beyond the depth range of current NEFSC trawl surveys, possibly using experimental research or supplemental surveys.

The Working Group made no progress on this RR.

Initiate aging studies for spiny dogfish age structures (e.g., fin spines) obtained from NEFSC trawl surveys and other sampling programs. These studies should include additional age validation and age structure exchanges. The WG notes that other aging methodologies (e.g., Canadian studies on radiometry) are also in development.

The Working Group reviewed preliminary results of NEFSC aging work for spiny dogfish. Preliminary results agree more with validated ages for Pacific dogfish, than with current estimates used for Northwest Atlantic dogfish. More work needs to be done to estimate growth and variation of length-at-age.

Additional analyses of the effects of environmental conditions on survey catch rates should be conducted.

The Working Group investigated the associations of temperature and depth with trawl survey densities. Examination of dogfish distributions in trawl surveys indicates greater concentrations closer to shore over the last five years.

Additional work on the stock-recruitment relationship should also be conducted with an eye toward estimation of the intrinsic rate of population increase.

More work needs to be done to estimate the relationship among males, females, and reproduction.

The SARC noted that the increased biological sampling of dogfish should be conducted and research trawl surveys. Maturation and fecundity estimates by length class will be particularly important to update. Additional work on the survey database to recover and encode information on the sex composition prior to 1980.

A sampling program to collect aging structures (2003) and maturity data (1998) for dogfish has been implemented on NEFSC surveys. Sex composition data from NEFSC spring and fall surveys from 1968 to 1972 were examined, and this historical information was included in this assessment.

6.9 Additional comments unrelated to the TOR

There were no additional comments unrelated to the TOR.

6.10 Recommendations for future assessments

Collect age data to estimate growth and variation of length-at-age. Estimates of asymptotic length are important.

Pup production and the effects of skewed sex ratio need to be investigated. This includes examining the reduction of average length of pups and the relationship between males, females, and pups (i.e. cannibalism, competition, and aggression).

More comprehensive data on discarding in the recreational and commercial fisheries is needed. This should include the amount discarded, length-frequency of discards, and survival rates.

The length tuned model should be improved and include all available data. The use of Stock Synthesis II should be considered.

6.11 Appendix

A simple model representing the female biomass. Growth, natural mortality and recruitment are combined into a single population change parameter p. This parameter is allowed to change over time as a linear trend to represent the increase in population growth rate as the average age in the population decreases increasing the average individual growth (see Figure 9.2 bottom right panel).

$$B_{1982} = B_{init}$$

$$B_{y+1} = B_y(1 + p_y) - C_y$$

$$p_y = \alpha + \beta(y - 1982)$$

$$-\ln L(\boldsymbol{\theta} \mid \mathbf{I}) = \sum_y \left(\ln[\sigma] + \frac{(\ln[qI_y] - \ln[B_y])^2}{2\sigma^2} \right)$$

Results of the analysis look at the sensitivity to growth and the time span of the data used. Note that negative log-likelihoods can not be compared among models that use different years of survey data. The model that only estimates the slope approximates a population close to virgin in 1982 and has a similar trend as in Figure 9.2 with recruitment balancing growth and mortality in 1982.

Model	Survey data	Q	Slope	Intercept	Growth 2005	-ln(like)
Growth trend Fig 9.2	1982-2005	1.61	0.0035	-0.0400	0.0405	-2.90
	1987-2005	1.14	0.0035	-0.0400	0.0405	-8.04
No growth	1982-2005	1.59	0.0000	0.0000	0.0000	-4.05
	1987-2005	1.21	0.0000	0.0000	0.0000	-7.77
Estimate trend	1982-2005	1.30	-0.0029	0.0487	-0.0175	-5.03
	1987-2005	0.54	0.0174	-0.0945	0.3046	-9.17
Estimate slope	1982-2005	1.05	0.0033	0.0000	0.0760	-4.66
	1987-2005	0.88	0.0030	0.0000	0.0698	-8.34

Annex III: Statement of Work

General

The Northeast Regional Stock Assessment Review Committee (SARC) meeting is a formal, multiple-day meeting of stock assessment experts who serve as a panel to peer-review tabled stock assessments and models. The SARC is the cornerstone of the Northeast Stock Assessment Workshop (SAW) process, which includes assessment development (SAW Working Groups or ASMFC technical committees), assessment peer review, public presentations, and document publication.

The Center for Independent Experts (CIE) shall provide a chair and two panelists for the 43rd Stock Assessment Review Committee panel. The panel will convene at the Woods Hole Laboratory of the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts, from June 6-12, 2006 to review four assessments (black sea bass, *Centropritis striata*; spiny dogfish, *Squalus acanthias*; ocean quahog clams, *Arctica islandica*; deep sea red crab, *Chaceon quinquedens*). In the days following the review of the assessments, the panelists will write independent review reports, and then the panel shall use these independent review reports to write the SARC Summary Report.

Specific Activities and Responsibilities

The CIE's deliverables shall be provided according to the schedule of milestones in the table below. The main CIE deliverable will be the SARC Summary Report that will provide key information for a presentation to be made by NOAA Fisheries at meetings of the New England and Mid-Atlantic Fishery Management Councils in mid-2006. The SARC Summary Report shall be an accurate and fair representation of the CIE panel viewpoint on how well each of the Terms of Reference of the SAW were completed (please refer to Annex 1 for the Terms of Reference).

The two SARC panelists' duties shall occupy a maximum of 14 days per person (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; and the several days following the meeting to produce the independent review reports and the SARC Summary Report).

The SARC chair's duties shall occupy a maximum of 19 days (i.e., several days prior to the meeting for document review; the SARC meeting in Woods Hole; several days following the meeting to lead the preparation of the SARC Summary Report; and several days after the meeting to finalize the SARC Summary Report).

Charge to panel

The panel is to determine and write down whether each Term of Reference of the SAW was or was not completed successfully during the SARC meeting. Specifically, for each SAW Term of Reference the panelists should determine: i) whether the work that was presented is acceptable based on scientific criteria (e.g. consider whether the data were adequate and used properly, the analyses and models were carried out correctly, and whether the conclusions are correct/reasonable); and ii) whether the work provides a scientifically credible basis for developing fishery management advice. The chair shall identify or facilitate agreement among the panelists for each Term of Reference of the SAW, where possible.

Roles and responsibilities

(1) Prior to the meeting

(SARC chair and panelists)
Review the reports produced by the Working Groups and read background reports.

(2) During the Open meeting

(SARC chair)
Act as chairperson, where duties include control of the meeting, coordination of presentations and discussion, making sure all Terms of Reference of the SAW are reviewed, control of document flow, and facilitation of discussion.

(SARC panelists)
For the four stock assessments, participate as a peer reviewer in panel discussions on assessment validity, results, recommendations, and conclusions. From a scientist/reviewer's point of view, determine whether each Term of Reference of the SAW was completed successfully. Terms of Reference that are completed successfully are likely to serve as a basis for providing scientific advice to management.

(3) After the Open meeting

(SARC panelists)
Each panelist shall prepare an independent review report addressing each Term of Reference of the SAW for each of the stock assessments reviewed. These independent review reports will be included as appendices of the SARC Summary Report. These reports need to specify and provide an explanation about whether each Term of Reference of the SAW was or was not completed successfully during the SARC meeting, using the criteria specified above in the "Charge to panel" statement.

During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments may be raised. Comments on these questions should be included in a separate section at the end of the independent report produced by each panelist.

(SARC chair)
Prepare a document summarizing the background to the work to be conducted as part of the SARC 43 process and summarizing whether the process was adequate to complete the Terms of Reference of the SAW. If appropriate, the chair will include suggestions on how to improve the process. This document will constitute the introduction to the SARC Summary Report.

(SARC chair and panelists)
The entire panel will prepare the main body of the SARC Summary Report. Each panelist and the chair will read all panelists' independent review reports with the purpose of discussing whether the panelists hold similar views on each Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar or a consensual view can be reached, the SARC Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the SARC Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the reviewers to reach an agreement if they can not reach one. The chair is not required to express the chair's opinion on each Term of Reference of the SAW, specifically because the chair's role is not that of an independent reviewer.

The contents of the SARC Summary Report will be approved by the panelists by the end of the SARC Summary Report development process, prior to the panel's dismissal and departure. The chair will complete all final editorial and formatting changes prior to the final submission of the SARC Summary Report to the CIE, in consultation with the panelists, as the chair deems necessary. The chair will provide the panelists with a final copy of the final SARC Summary Report provided to the CIE.

The SARC Summary report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, this Report should state why that Term of Reference was or was not completed successfully. See Annex 2 for further details on the SARC Summary report contents.

The milestones and schedule are summarized in the table below. The SARC panelists shall begin writing their independent review reports as items are completed during the Workshop, and the SARC chair and panelists shall develop the SARC Summary Report when the SAW-43 open meeting is concluded.

No later than June 19, 2006, the SARC Chair should submit the SARC Summary Report to the CIE for review[1]. The SARC Summary Report shall be addressed to "University of Miami Independent System for Peer Review," and sent to Dr. David Sampson, via e-mail to David.Sampson@oregonstate.edu and to Mr. Manoj Shivlani via e-mail to mshivlani@rsmas.miami.edu

Milestone	**Date**
Workshop at Northeast Fisheries Science Center (NEFSC) (begin writing SARC Summary Report, as soon as Workshop ends)	June 6-9, 2006
SARC Chair and reviewers meet to prepare draft SARC Summary Report	June 10-12

[1] All reports will undergo an internal CIE review before they are considered final.

SARC Chair provides the draft SARC Summary Report to CIE for review	June 19
CIE provides reviewed SARC Summary Report to NMFS COTR for approval	July 3
COTR notifies CIE of approval of reviewed SARC Summary Report	July 5
CIE provides final SARC Summary Report with signed cover letter to COTR	July 6
COTR provides final SARC Summary Report to NEFSC contact	July 6, 2006

The SAW Chairman will assist the SARC chair prior to, during, and after the meeting in ensuring that documents are distributed in a timely fashion.

NEFSC staff and the SAW Chairman will make the final SARC Summary Report available to the public. Staff and the SAW Chairman will also be responsible for production and publication of the collective Working Group papers, which will serve as a SAW Assessment Report.

NEFSC Contact person and SAW Chairman:
Dr. James R. Weinberg, NEFSC, Woods Hole, MA. 508-495-2352,
James.Weinberg@noaa.gov

Submission and Acceptance of Consultants' Reports

The CIE shall provide via e-mail the final SARC Summary Report in pdf format to Dr. Stephen K Brown (stephen.k.brown) for review based on compliance with this Statement of Work by NOAA Fisheries and approval by the COTR, Dr. Stephen K. Brown, by July 3, 2006. The COTR shall notify the CIE via e-mail regarding acceptance of the report by July 5, 2006. Following the COTR's approval, the CIE will provide the final SARC Summary Report with digitally signed cover letter to the COTR by July 6, 2006.

ANNEX 2: Contents of SARC Summary Report

1.
The main body of the report shall consist of an introduction prepared by the chair that will include the background, a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment reviewed, the report should address whether each Term of Reference of the SAW was completed successfully. For each Term of Reference, the SARC Summary Report should state why that Term of Reference was or was not completed successfully. The report should determine whether the work that was presented is acceptable based on i.) scientific criteria [e.g. consider whether the data were adequate and used properly, the analyses and models were carried out correctly, and whether the conclusions are correct/reasonable] and ii.) whether the work provides a scientifically credible basis for developing fishery management advice. If the panel does not reach an agreement on a Term of Reference, the report should explain why.

The report shall be prefaced with an executive summary that provides brief (1-2 sentences) summaries of the conclusions for each Term of Reference.

2.

The report shall also include as separate appendices the independent review reports prepared by each panelist, the bibliography of all materials provided during SAW 43, and any papers cited in the panelists' reports, along with a copy of the Statement of Work.

The report shall also include as a separate appendix the Terms of Reference used for SAW 43, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panelist advice.

Annex IV: Terms of Reference for the 43rd Northeast Regional Stock Assessment Workshop

Meeting Dates: June 6-12, 2006

*Note: This ordering does not necessarily reflect the order on the SARC Agenda

Ocean quahog - (Invertebrate Working Group)

1. Characterize the commercial and recreational catch including landings and discards.

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2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

3. Either update or re-estimate biological reference points (BRPs), as appropriate.

4. Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

5. Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

6. If possible,

   a. provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and

   b. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

7. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

Spiny dogfish - (Southern Demersal Working Group)

1. Characterize the commercial and recreational catch including landings and discards.

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2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

3. Either update or re-estimate biological reference points (BRPs), as appropriate.

4. Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

5. Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

6. Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

7. If possible,

    a. provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and

    b. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

8. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

Deep-sea red crab - (Invertebrate Working Group)

1. Characterize the commercial and recreational catch including landings and discards.

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2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates. If possible, also include estimates for earlier years.

3. Either update or re-estimate biological reference points (BRPs), as appropriate.

4. Evaluate current stock status with respect to the existing BRPs, as well as with respect to new or re-estimated BRPs (from TOR 3).

5. Recommend what modeling approaches and data should be used for conducting single and multi-year stock projections, and for computing TACs or TALs.

6. If possible,

    a. provide numerical examples of short term projections (2-3 years) of biomass and fishing mortality rate, and characterize their uncertainty, under various TAC/F strategies and

    b. compare projected stock status to existing rebuilding or recovery schedules, as appropriate.

7. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in recent SARC-reviewed assessments.

Black sea bass - (Southern Demersal Working Group)

1. Characterize the commercial and recreational catch including landings and discards.

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2. Describe temporal trends in abundance and size-structure based on data from NEFSC surveys. When possible, characterize the uncertainty of point estimates. Describe data from other surveys, as appropriate.

3. Describe migration patterns based on data from the recent tagging study.

4. Estimate annual rates of fishing mortality and total mortality, based on the recent tagging study. Characterize the uncertainty of those estimates.

5. Evaluate current stock status with respect to the existing BRPs.

6. Perform sensitivity analyses to determine the impact of uncertainty in the recreational data on the assessment results.

7. Review, evaluate and report on the status of the SARC/Working Group Research Recommendations offered in the previous SARC-reviewed assessment.